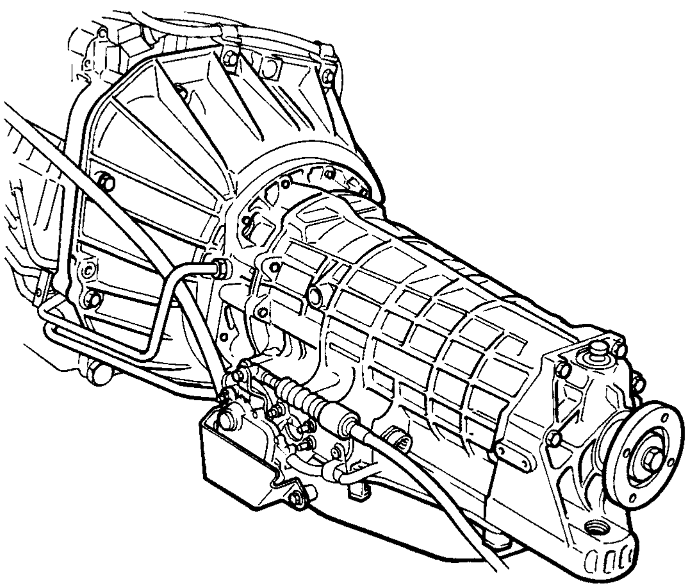
BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH II
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY

BY APPOINTMENT TO
HER MAJESTY QUEEN ELIZABETH
THE QUEEN MOTHER
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY

BY APPOINTMENT TO
HIS ROYAL HIGHNESS THE PRINCE OF WALES
MANUFACTURERS OF DAIMLER AND JAGUAR CARS
JAGUAR CARS LIMITED COVENTRY

JAGUAR

ZF Automatic Transmissions Service Manual



Published by Product Development & Publications
JaguarCars Limited

Part of *set* - JJM 10 04 12 / 50

CONTENTS

FOREWORD

This manual provides information relevant to the servicing of ZF Automatic Transmission Units **4 HP 22** and **4 HP 24 E** (irrespective of the vehicle range to which the unit is fitted). The manual should be used in conjunction with the relevant Vehicle Service Manual (VSM) and Electrical Diagnostic Manual (EDM).

It assumes that the transmission has been removed from the vehicle, in accordance with the Vehicle Service Manual, and is in a clean condition and all service tools and materials are available.

The manual is divided into two sections covering the ZF **4 HP 22** and ZF **4 HP 24** E and each section is divided into sub–sections covering:

- Service Information
- General Description
- Hydraulic Circuit Diagrams
- Fault Diagnosis
- Service Repair Operations.

An index can be found at the rear of the manual.

Note: For information relating to in–vehicle operations, refer to the Vehicle Service Manual.

I.

Illustration	Jaguar Number	Description	Notes
To be issued			

II. TORQUE TIGHTENING SPECIFICATIONS

Fixing	Tightening Torque (Nm)
To be issued	

Description	Uses	Notes
To be issued		

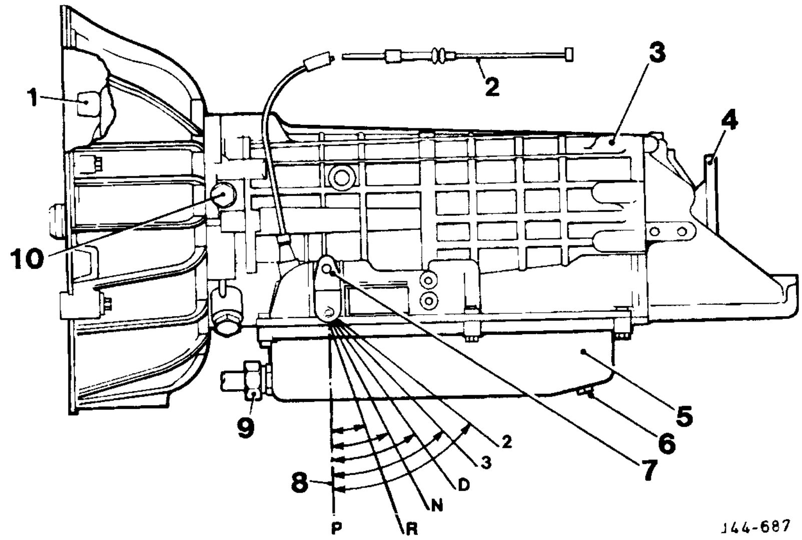
Item	Description		Data
Transmission fluid:	Capacity		8,0 Liters
Transmission fluid type:	Fill		Esso 2D
	Top-up		Esso 2D, 2E or 3
Transmission weight: (including torque converter)			74,75 kg
Transmission Ratios:	1st		2,48: 1
	2nd		11,481
	3rd		1,00: 1
	4th		0,73: 1
	Reverse		2,09: 1
Torque Converter:	Stall speed		2100 RPM ± 150 RPM
Transmission unit pressures:	Drive:	Idle (stationary)	630 – 710 kPa
	Drive:	Full Throttle (stall)	780 – 950 kPa
	Reverse:	Idle (stationary)	1070 – 1150 kPa
	Reverse:	Full Throttle (stall)	1620 – 1780 kPa

IV. Service Data (continued)

Item	Description	Data
Transmission fluid:	Capacity	9,5 Liters
Transmission fluid type:	Fill	Esso 2D
	TOP-UP	Esso 2D, 2E or 3
Transmission weight: (including torque converter)		79,65 kg
Transmission Ratios:	1st	2,48: 1
	2nd	1,48:1
	3rd	1,00:1
	4th	0,73: 1
	Reverse	2,09: 1
	Final drive	3,58: 1
Torque converter:	Nominal size (diameter)	280mm
	Torque	322 N m @ 2000 RPM
	Stall speed UK Specification	2000 RPM (+ 150 RPM)
	Federal Specification	1900 RPM (+ 150 RPM)
	Ratio	2,12:1 @ Stall
Gear train end-float		0,2mm to 0,4mm
Electrical data		
Solenoid valves;	MV1, MV2 and MV3	28 - 60 ohms (33,5 ohms @ 20C)
	Pressure regulator solenoid valve	5 - 7 ohms
	Output shaft sensor	300 ohms (± 10%)
	Sensor air gap	0,5mm to 1,0mm

1.1 ZF 4 HP 22 TRANSMISSION, GENERAL DESCRIPTION

The ZF Automatic Transmission covered in this section comprises a hydrodynamic torque converter, four speed gear train and a hydraulic transmission control unit.



1. Torque converter
2. Throttle cable
3. 4-speed gear train
4. Output flange
5. Transmission control unit
6. Oil outlet (drain plug)
7. Selector cable attachment
8. Selector lever positions (see text)
9. Dipstick / oil filler tube
10. Oil cooler connection

Fig. ZF HP 22 ·ansmission

The transmission provides six gearshift positions:

- Position 'P': Park – in this position the driven wheels are mechanically locked at the transmission.
- Position 'R': Reverse – reverse gear selected.
- Position 'N': Neutral – engine disconnected from driveline and wheels.
- Position 'D': Drive – all four speed ranges are selected automatically with lock-up available in top gear only.
- Position '3': automatic selection of the lowest three speed ranges only.
- Position '2': automatic selection of the lowest two speed ranges only, transmission is prevented from shifting up to the third and top speed ranges.

Immediate selection of a lower ratio is also available by 'kick-down' (pressing the accelerator down beyond the normal full throttle position) for example when overtaking.

1.1.1 *Torque Converter*

The torque converter serves two main functions: it acts as a fluid coupling between engine and transmission geartrain and it provides multiplication of engine torque when required.

The torque converter consists of an impeller, a turbine and a stator which is mounted on a one-way clutch. The converter cover is fixed to the impeller to seal the three elements within a common housing forming a closed circuit through which oil flows when the transmission is in operation. The impeller is therefore connected to the engine and rotates at engine speed when the engine is operating.

Torque multiplication is at its greatest when the vehicle is driven away from standstill. The stator bears against the housing through its one-way clutch and deflects the oil so that the flow is accelerated. As road speed builds up, the impeller and turbine wheels turn at almost the same speed, so that the stator ceases to accelerate the oil flow and instead is disengaged from the housing and turns freely in the flow of oil. At this stage, the torque converter acts as a fluid coupling.

The torque converter acts in all four forward gears and in reverse. The converter lock–up clutch closes in 4th gear at a point depending on road speed and accelerator position; engine power is then transmitted by purely mechanical means.

A low–loss oil pump in the front of the transmission housing supplies the converter, the automatic gear shift and the lubrication circuit; oil is drawn from a sump in the bottom of the gear train housing through a filter. The pump drive gear is keyed to the converter impeller hub and therefore turns when the engine is running, thereby pressurizing the oil.

1.1.2 Four–speed Epicyclic Gear Train

The torque converter drives a mechanical epicyclic gear train providing four forward ratios and reverse. Individual ratios are obtained by coupling together the various parts of the gear train by means of hydraulically actuated multi–disc clutches and brakes; built in freewheels permit gear shifts without any interruption of the power flow. Operation of the clutches and gear sets is described in sub–section **1.1.3.**

Each epicyclic (or planetary) gear set comprises a central, sungear, an annulus and a planetary carrier which supports four small planet gears or pinions. Two gear sets are used in this transmission. A compound gear set comprising front annulus and planet carrier, rear annulus and planet carrier and a common sungear transmits the drive in all gears except REVERSE; a single planetary carrier, annulus and sungear transmits the fourth gear drive. The table below shows the resulting clutch operation in the selected gear ratios.

Selected ratios	Resulting clutch operation
D_1, 3_1, 2_1	A Clutch drives annulus clockwise E Clutch & OWC drives output shaft clockwise
D_2, 3_2, 2_2	A Clutch drives annulus clockwise C1 Clutch holds sungear against anti-clockwise C Clutch & OWC holds sungear against anti-clockwise
D_3, 3_3, 2_3	A Clutch drives annulus clockwise B Clutch drives sungear clockwise C Clutch & OWC holds sungear against anti-clockwise
D_4	A Clutch drives annulus clockwise B Clutch drives sungear clockwise C Clutch & OWC holds sungear against anti-clockwise
R	B Clutch drives sungear clockwise D Clutch holds carrier against clockwise E Clutch & OWC drives output shaft anti-clockwise
Park, Neutral	E Clutch & OWC applied (hydraulics)

OWC = one way clutch

1.1.3 Operation Of Gear Train Clutches

1st Gear

Clutches 'A' and 'E' are engaged.

The front planet gear carrier of gear set '1' is locked against the housing of through freewheel '2' when the engine is pulling, but is over–run when the engine is coasting.

Epicyclic gear set '2' rotates as a solid block with the second planet set.

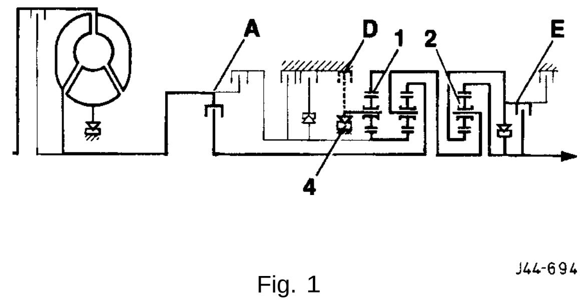


Fig. 1

2nd Gear

Clutches 'A','C1','C' and 'E' are engaged.

Freewheel '4' over–runs.

Clutches 'C1' and 'C' lock the sun gear to the housing.

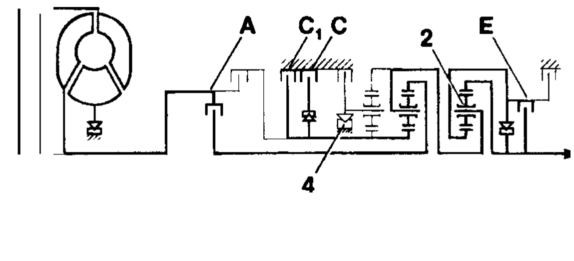


Fig. 2

3rd Gear

Clutches 'A','B','C' and 'E' are engaged.

Freewheels '4' and '5' are over–run.

Epicyclic gear sets '1' and '2' rotate as a solid block at ratio of 1:1.

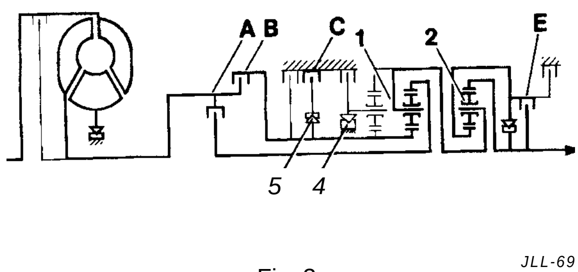


Fig. 3

4th Gear

Clutches 'A','B','C' and 'F' are engaged.

Freewheels '3','4' and '5' are over–run.

Epicyclic gear set '1' rotates as a solid block.

The hollow shaft with the sun wheel of epicyclic gear set '2' is locked.

Above a predetermined road speed, lock–up clutch '6 locks torque converter '7' solid to prevent slip.

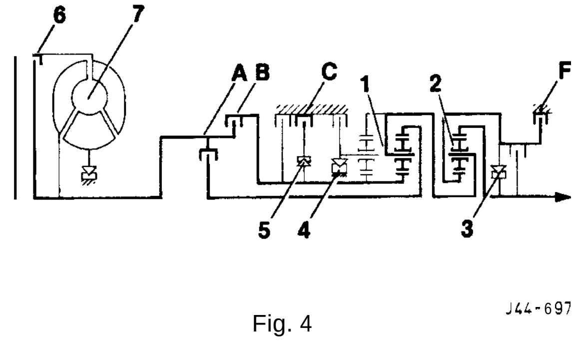


Fig. 4

Reverse Gear

Clutches 'B','D' and 'E' are engaged.

As the front planet gear carrier of epicyclic gear set '1' is locked, the direction of output shaft rotation is reversed.

Epicyclic gear set '2' also rotates as a solid block.

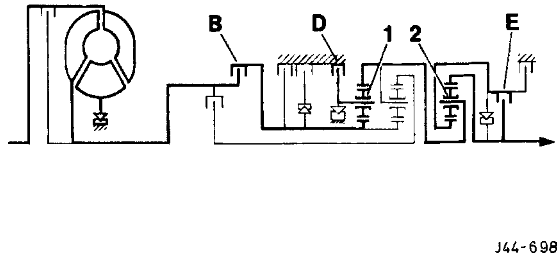


Fig. 1

1.1.4 Transmission Output Shaft Extension Housing

This housing contains the output shaft and speed governor and the parking lock mechanism. The governor comprises two spring loaded valves, a spindle and a weight; the governor is influenced by centrifugal and hydraulic forces and supplies a varying hydraulic pressure.

The parking lock pawl operates on a toothed wheel attached to the output shaft speed governor; the mechanism is operated from the selector (position 'P') by actuator rod.

1.1.5 Transmission Control Unit

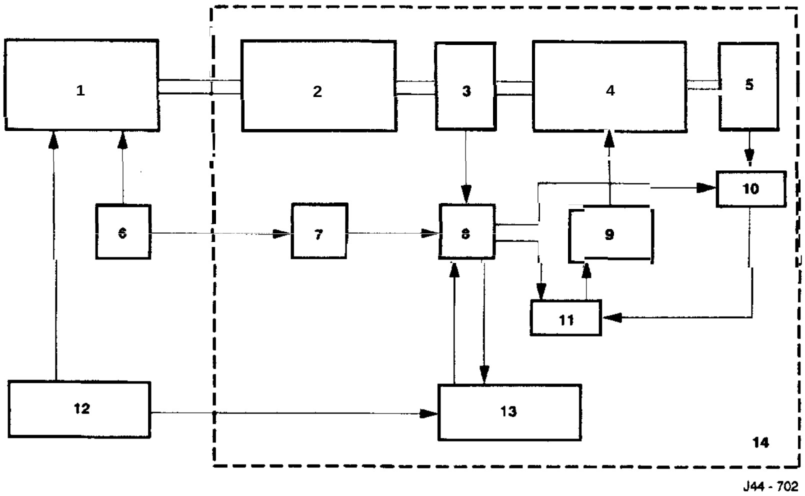
The hydraulic control unit comprising a series of valve blocks housing the manual (selector) valve, control pistons and pressure valves, is attached to the underside of the transmission housing; the unit controls the operation of the gear train clutches and directs oil pressure to the appropriate system components (refer to illustrations, pages 5 to 7) to operate the transmission. The valve blocks are connected to a main gallery plate.

Line pressure from the hydraulic pump is supplied initially to the pressure regulating valve, manual valve, governor, 3–4 shift valve, 'E' clutch and damper, throttle valve, modulator valve and torque converter pressure (and reversing) valve. The function of each of the valves in the control unit and the governor valve is summarised in the table below.

Valve	Summary of function
Pressure regulating	Varies line pressure as required
1–2 shift valve	Line pressure to C & C1 clutch valves and dampers
2–3 shift valve	Line pressure to C1 clutch (2nd); line pressure to B clutch (3rd)
2nd gear inhibit	Line pressure to 2–3 shift valve
3–4 shift valve	Line pressure to E clutch (3rd); line pressure to F clutch (4th)
Throttle valve	Throttle pressure to modulator and shift valves
Modulator	Modulated throttle pressure fed to clutch dampers and valves
Converter & Reversing	Line pressure to lock-up clutch; lubrication oil to cooler
Reverse inhibit	Line pressure to B & D clutches
F Clutch inhibit	Governor pressure to 3–4 shift valve inhibited in reverse
Converter clutch hysteresis	Governor pressure to converter clutch hysteresis valve
Converter clutch lock-up	Line pressure to converter pressure valve (D4 selected)
Converter clutch damper	Aids quality of converter clutch application
Clutch valves & Dampers	Aids quality of clutch application relevant to modulator & line pressures
Governor	Varies pressure in accordance with road speed

1.1.6 Gearshift Selection

Gearshift selection is by movement of the shift lever which through a selector cable causes repositioning of the manual (selector) valve to direct oil pressure to the required shift valve. The automatic shift points are determined by accelerator position and road speed: throttle movement moves a cam on the throttle valve, directing oil pressure to the shift valves and modulator valve, road speed modulates hydraulic pressure through a centrifugal governor driven by the transmission output shaft. Operation of the hydraulic control system is shown diagrammatically in the circuit diagrams on the following pages.



1. Engine
2. Torque converter
3. Pump
4. Clutch & gears
5. Governor
6. Shift
7. Solenoid valve
8. Pump regulator valve
9. Damper
10. Governor valve
11. Shift valve
12. Kickdown cable & throttle cam
13. Throttle / modulator valves
14. Transmission housing

Fig. 1 Schematic Diagram of Hydraulic Control

1.1.7 Throttle Valve Mechanism (kick–down)

The throttle valve or 'kick–down' mechanism comprises a cable connected between throttle body pedal and the throttle valve cam/ quadrant located on the selector valve shaft; the cam operates the throttle valve housed within the throttle valve block. The travel of the valve is proportional to throttle positions and alters shift speeds and pressures during gearshifts to take account of throttle position. The mechanism also provides for immediate selection of a lower

ratio (eg when overtaking) by depressing the accelerator beyond the normal full–throttle position. 'Kick–down' is operated by movement of the throttle cable into the 'kick–down' position causing full movement of the throttle valve and directing oil flow to the shift valves.

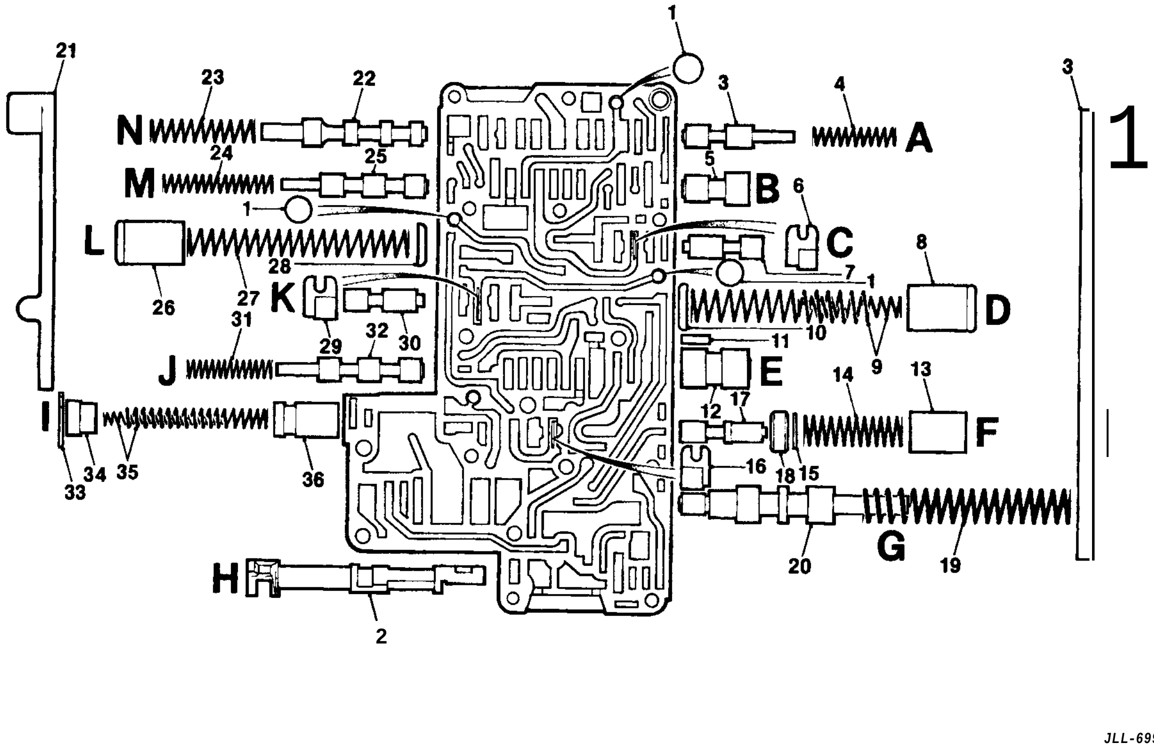
1.1.8 Starter Inhibit Switch

The starter inhibit switch prevents the starter motor from being operated when the shift lever is not in position 'P' – Park or position 'N' – Neutral. The switch is located in the gear selector housing.

1.1.9 Gearshift Interlock

A brake pedal/shift lever interlock is incorporated in the gearselector mechanism. The shift lever may only be moved from the 'P' – Park position if the ignition key switch is in position 'II', and the foot brake pedal is applied. The ignition key cannot be removed from the ignition switch unless the shift lever is in the 'P' –Park position. Once the ignition key has been removed, the shift lever is locked in the park position.

The gearshift interlock is operated by an electrical solenoid located adjacent to the selector; an override latch is incorporated into the mechanism to enable the gearshift interlock to be manually overridden in the event of electrical failure or when towing.

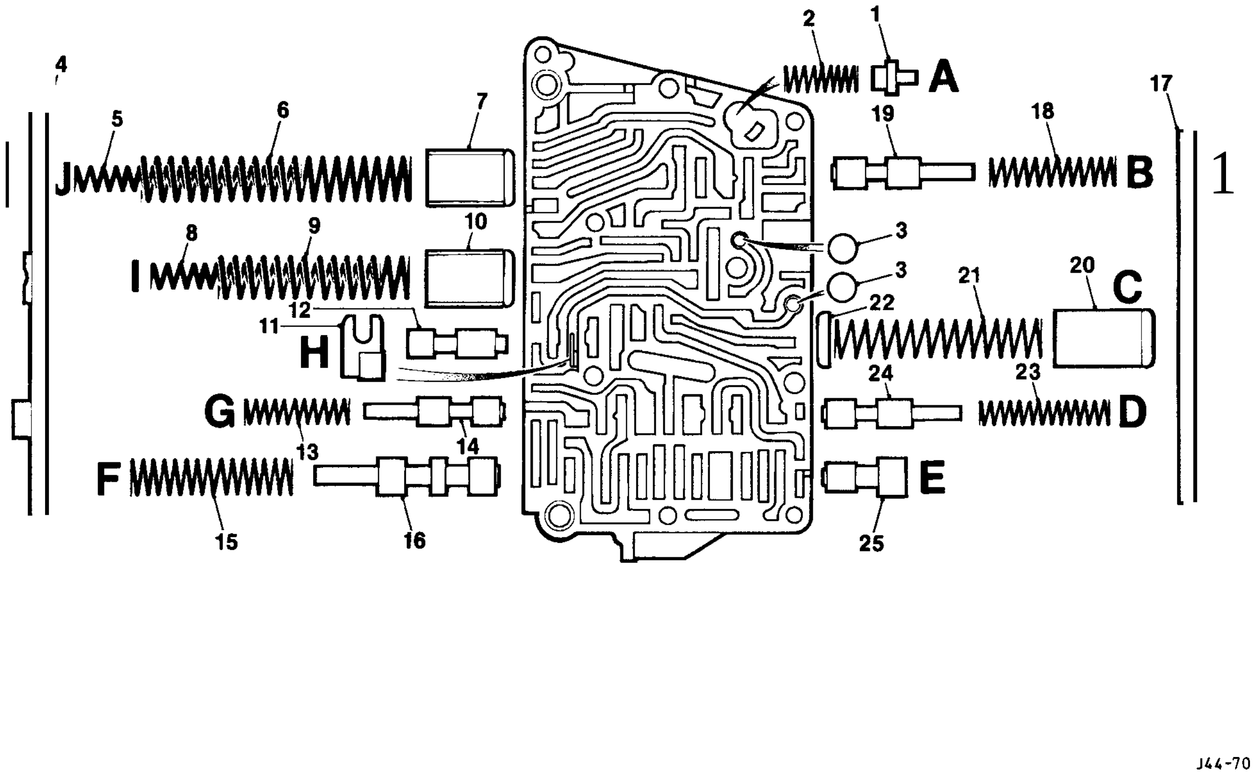


A. C1 Clutch valve
B. 2–3 shift valve piston
C. C clutch damper valve
D. B clutch damper
E. 1–2 shift valve piston
F. D clutch valve and piston
G. Pressure regulating valve

H. Manual (selector) valve
I. A clutch damper
J. 1–2 shift valve
K. B clutch damper valve
L. C clutch damper
M. 2–3 shift valve
N. Converter pressure valve

Note: Numerical annotations are not used in this application.

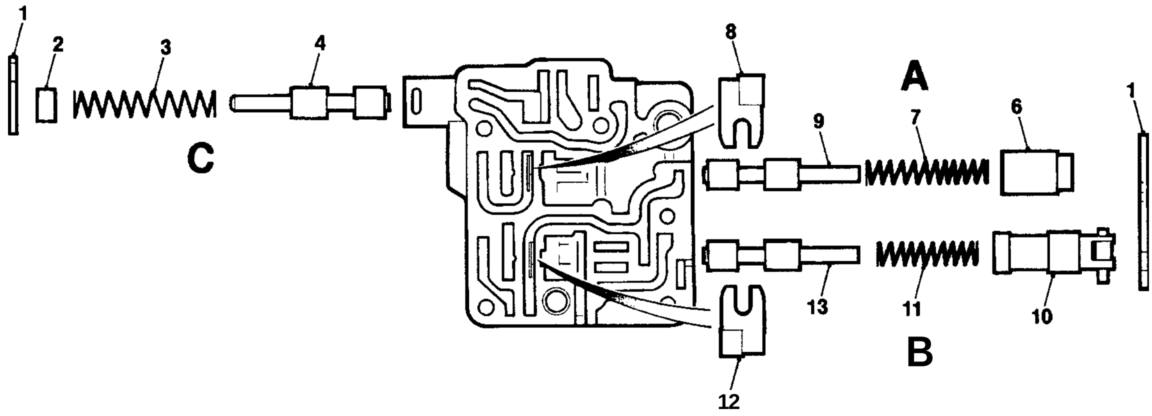
Fig. 1 Manual Valve Block



A.	One way valve (lubrication)	F.	3–4 shift valve
B.	2nd gear inhibit valve	G.	1st gear inhibitvalve
C.	F clutch damper	H.	F clutch valve
D.	F clutch inhibit valve (reverse)	I.	E clutch damper
E.	3–4 shift valve piston	J.	C1 clutch damper

Note: Numerical annotations are not used in this application.

Fig. 1 Rear Valve Block



A. Modulator valve
B. Throttle valve / Kick-down valve
C. Reverse inhibit valve

Note: Numerical annotations are not used in this application.

Fig. 1 Throttle Valve Block

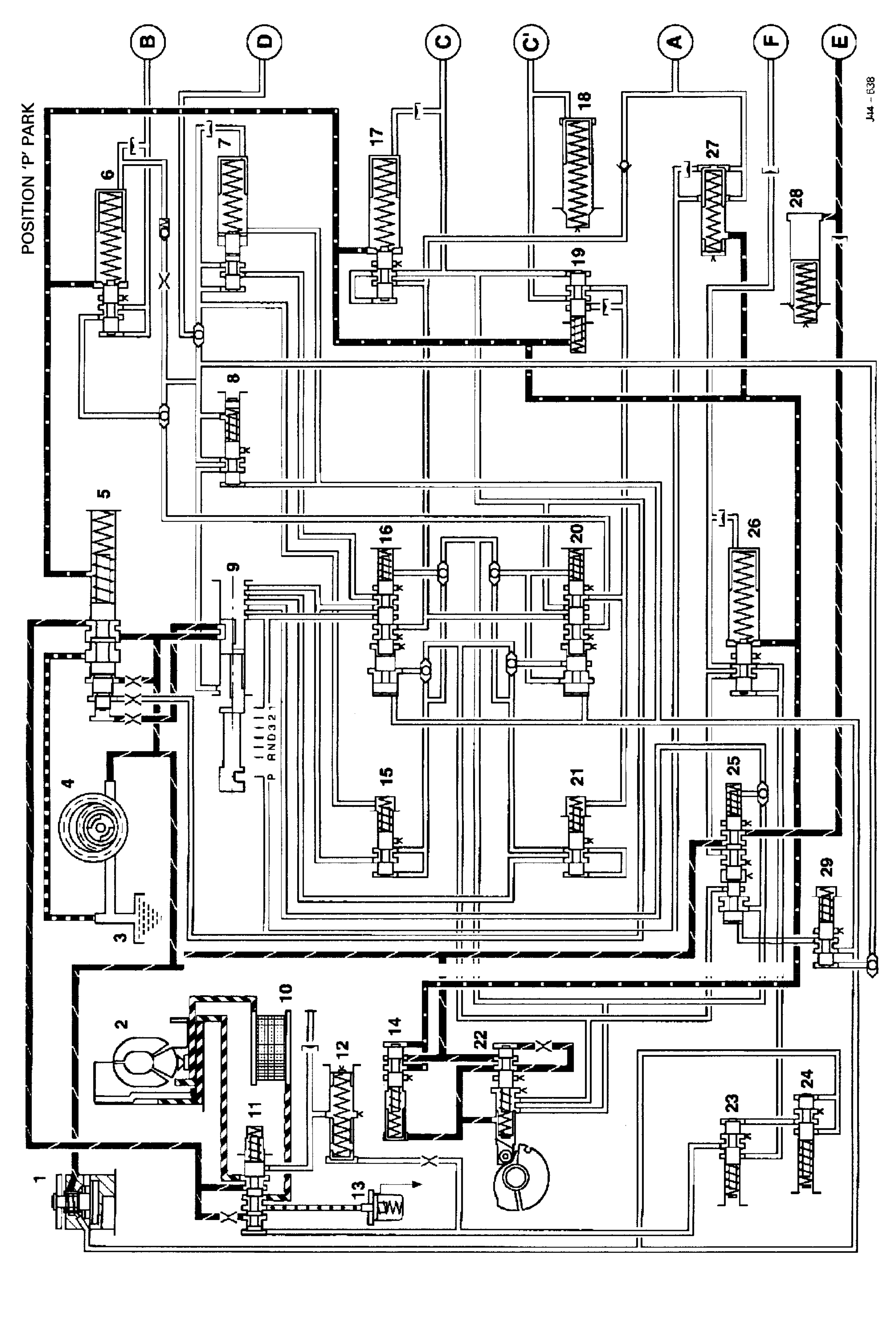
1.2 HYDRAULIC CIRCUIT DIAGRAMS

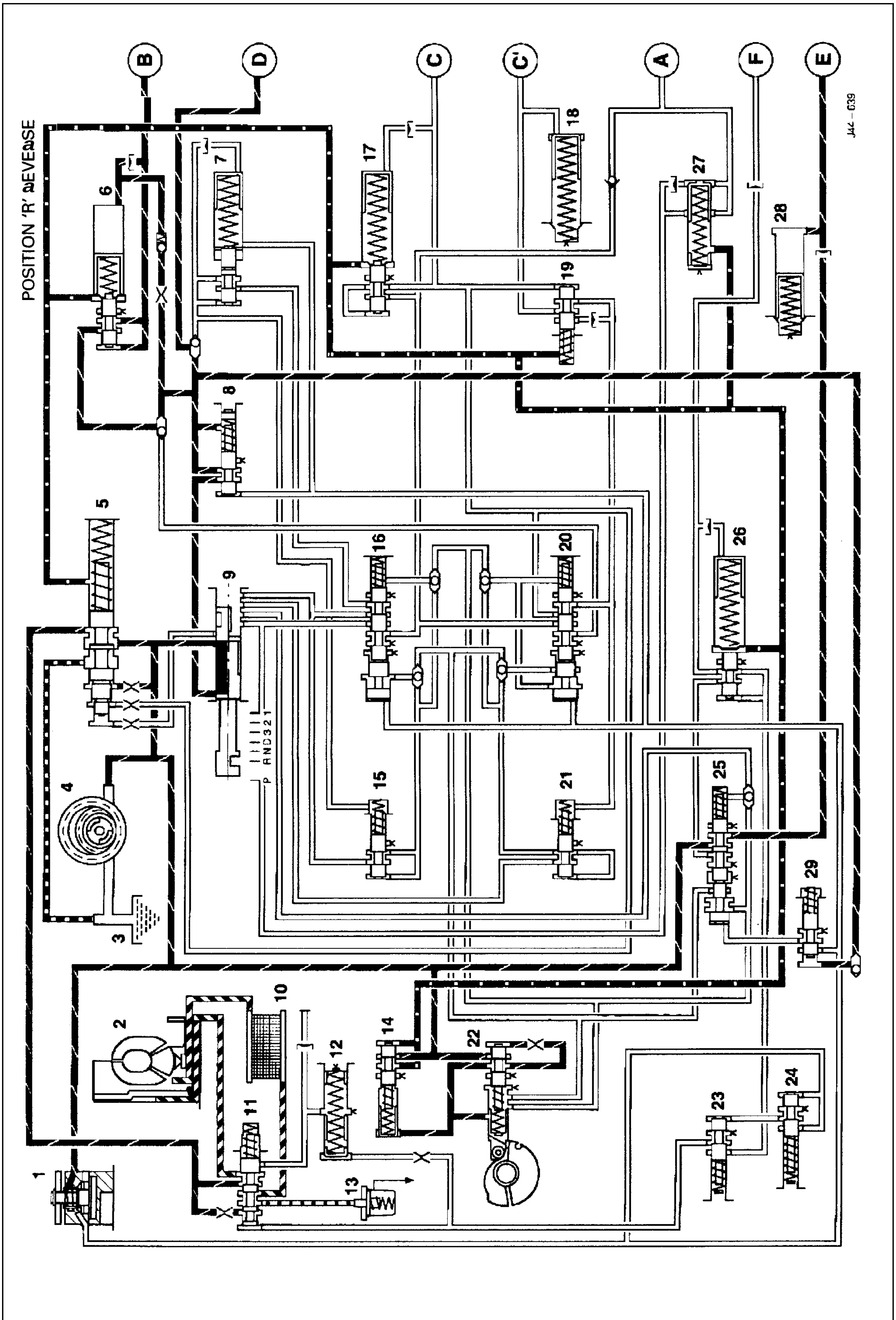
Key To Hydraulic Circuit Diagrams (commencing on page 10)

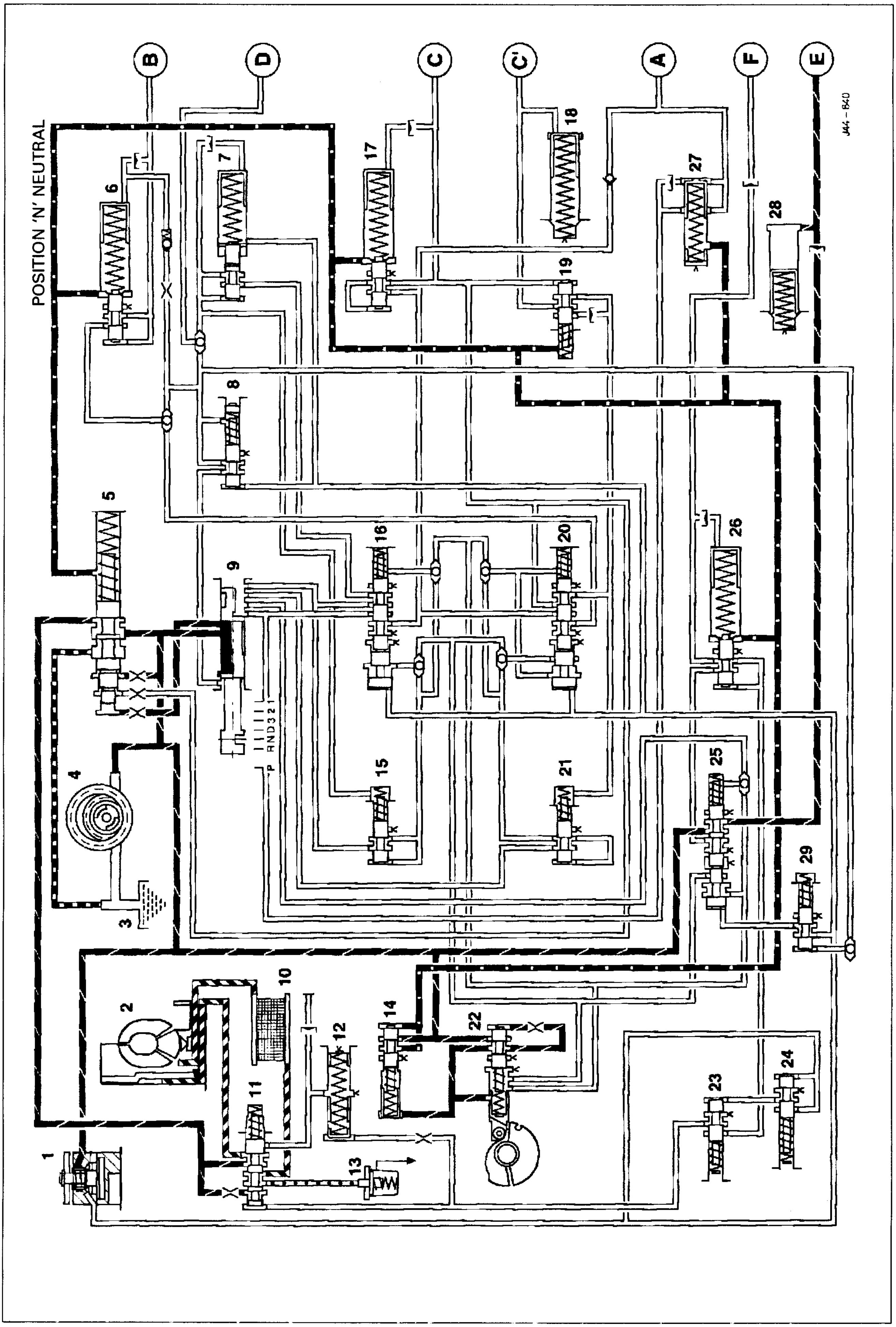
1. Governor
2. Torque Converter
3. Sump
4. Pump
5. Pressure Regulating Valve
6. Clutch 'B' Valve And Damper
7. Clutch 'D' Valve And Damper
8. Reverse Gear Inhibit
9. Manual Valve
10. Oil Cooler
11. Converter And Reversing Valve
12. Converter Clutch Damper
13. One-way Valve
14. Modulator Valve
15. 1st Gear Inhibit
16. 1 - 2 Shift Valve
17. Clutch 'C' Valve
18. Clutch 'C^1' Damper
19. Clutch 'C^1' Valve
20. 2 - 3 Shift Valve
21. 2nd Gear Inhibit
22. Throttle Valve
23. Converter Clutch Lock-up Control Valve
24. Converter Clutch Hysteresis Valve
25. 3 - 4 Shift Valve
26. Clutch 'F' Valve And Damper
27. Clutch 'A' Damper
28. Clutch 'E' Damper
29. Clutch 'F' Inhibit Valve (Reverse)

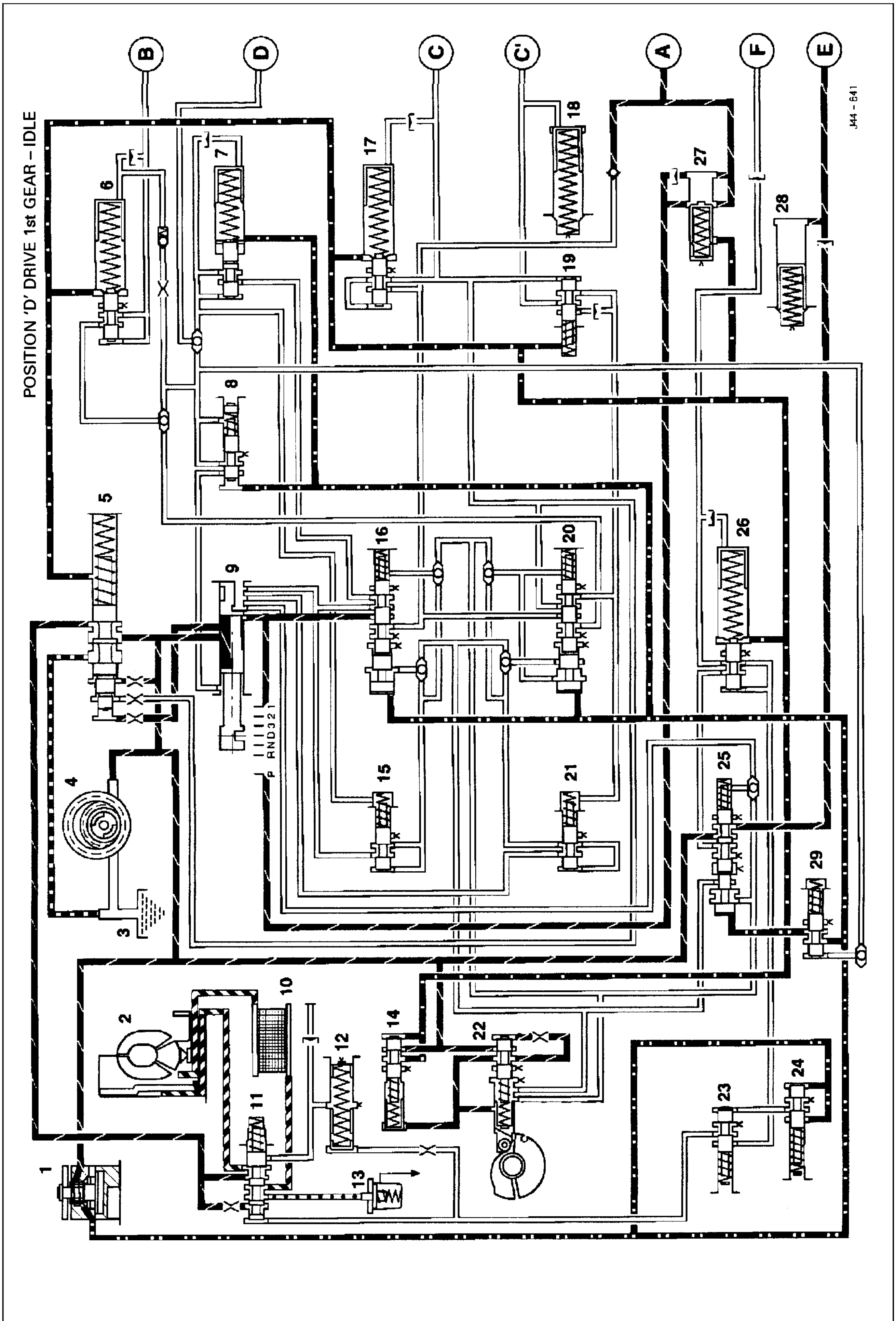
A Clutch 'A'
B Clutch 'B'
C Clutch 'C'
C^1 Clutch 'C^1'
D Clutch 'D'
E Clutch 'E'
F Clutch 'F'

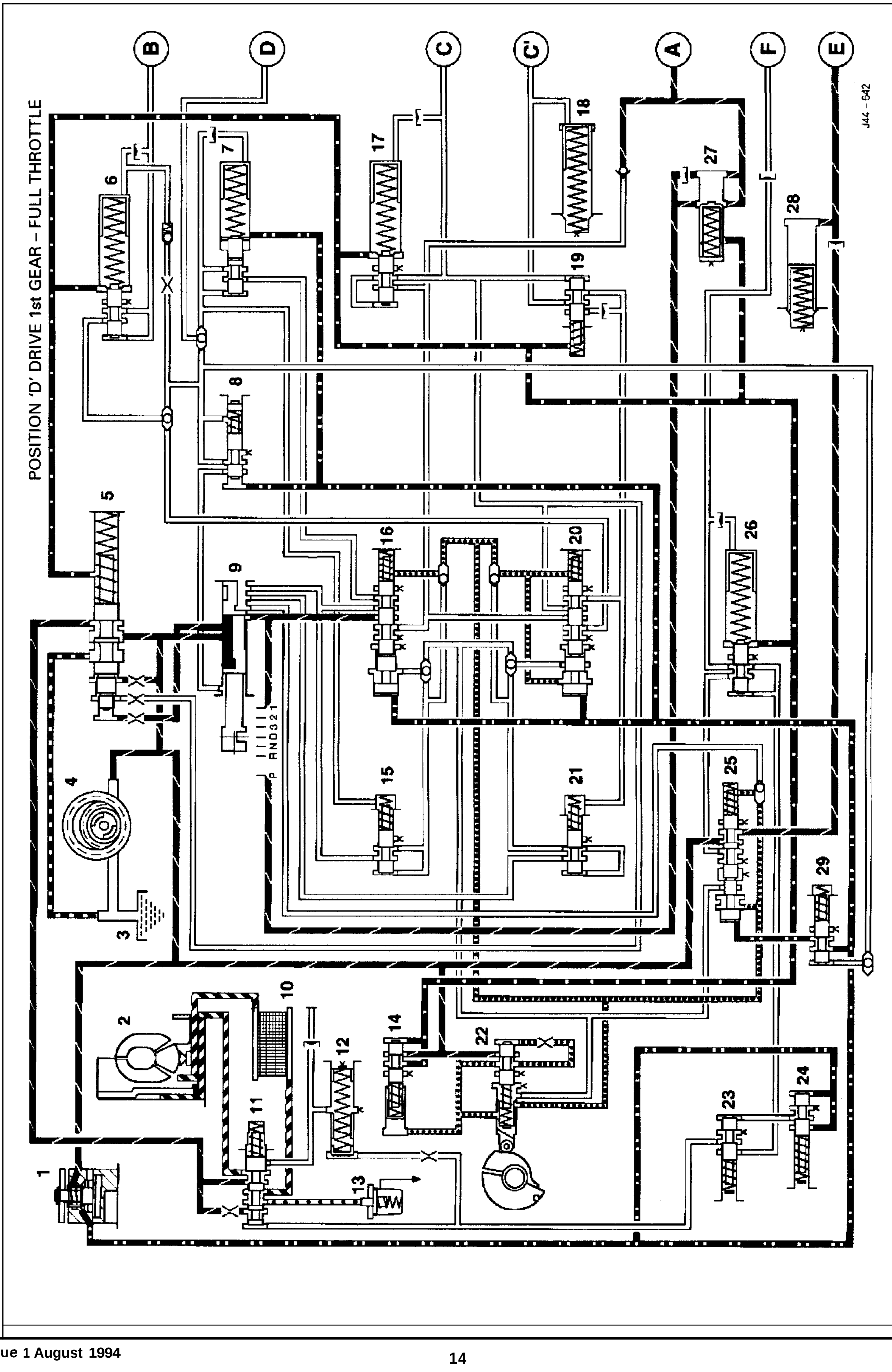
I Exhaust
II Throttle
III Orifice
IV Branch
V Main Pressure
VI Converter Pressure
VII Throttle Pressure
VIII Governor Pressure
IX Locking Pressure
X Modulation Pressure
XI Pump Pressure
XII Lubrication Pressure

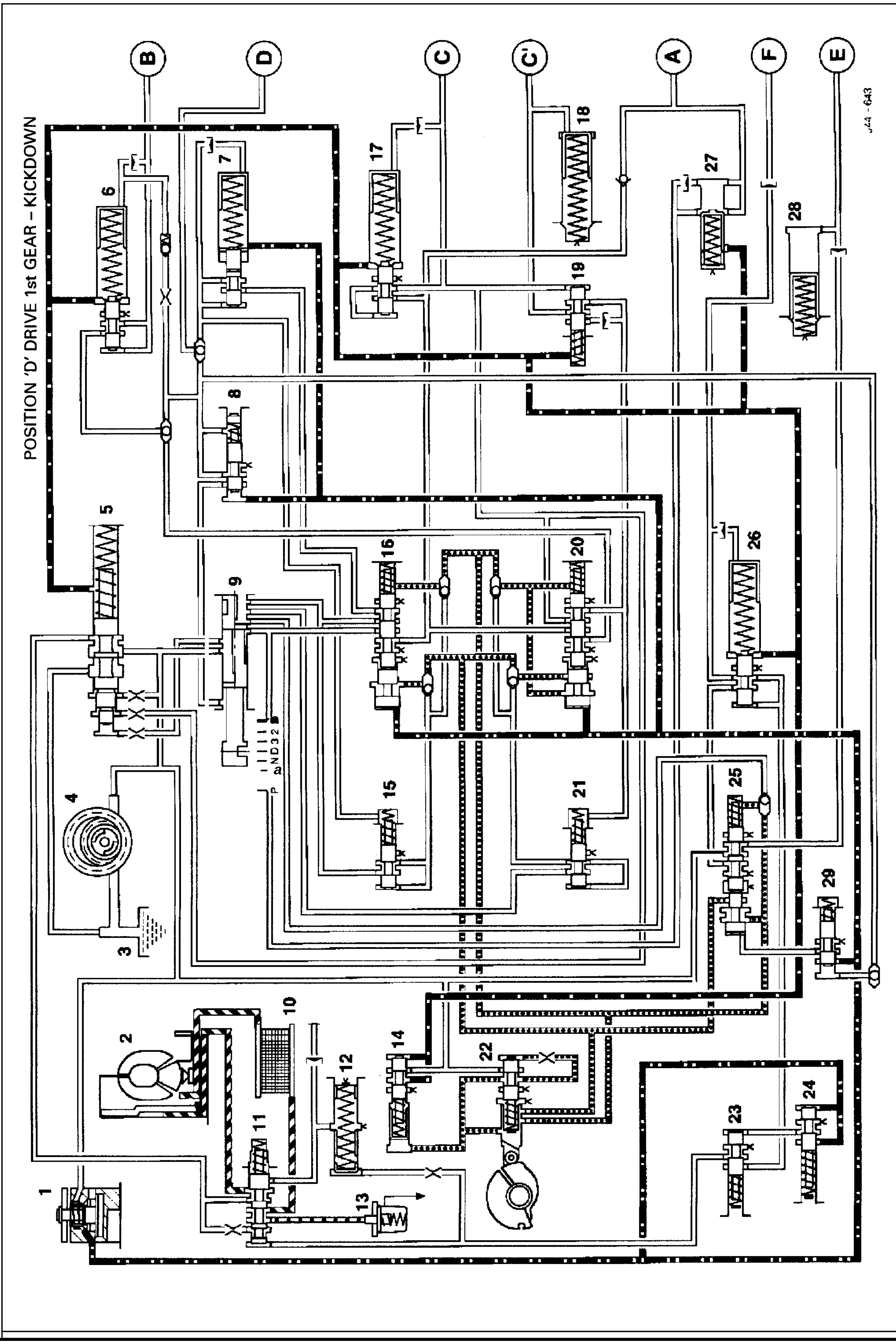

POSITION 'P' PARK
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C'
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P RND321
J44 - 638

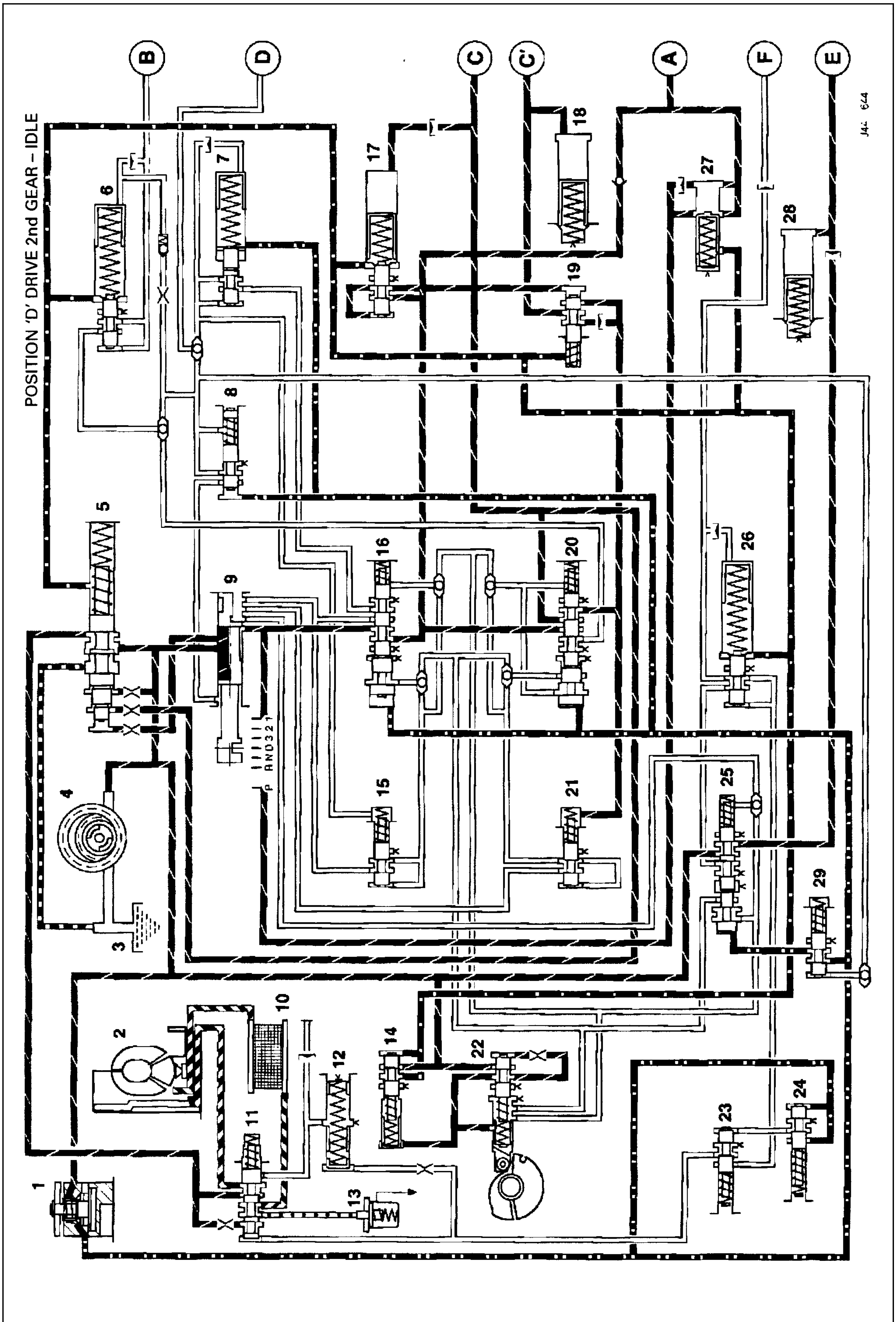

POSITION 'R' REVERSE
B
D
C
C'
A
F
E
P R N D 3 2 1
J42 - 639

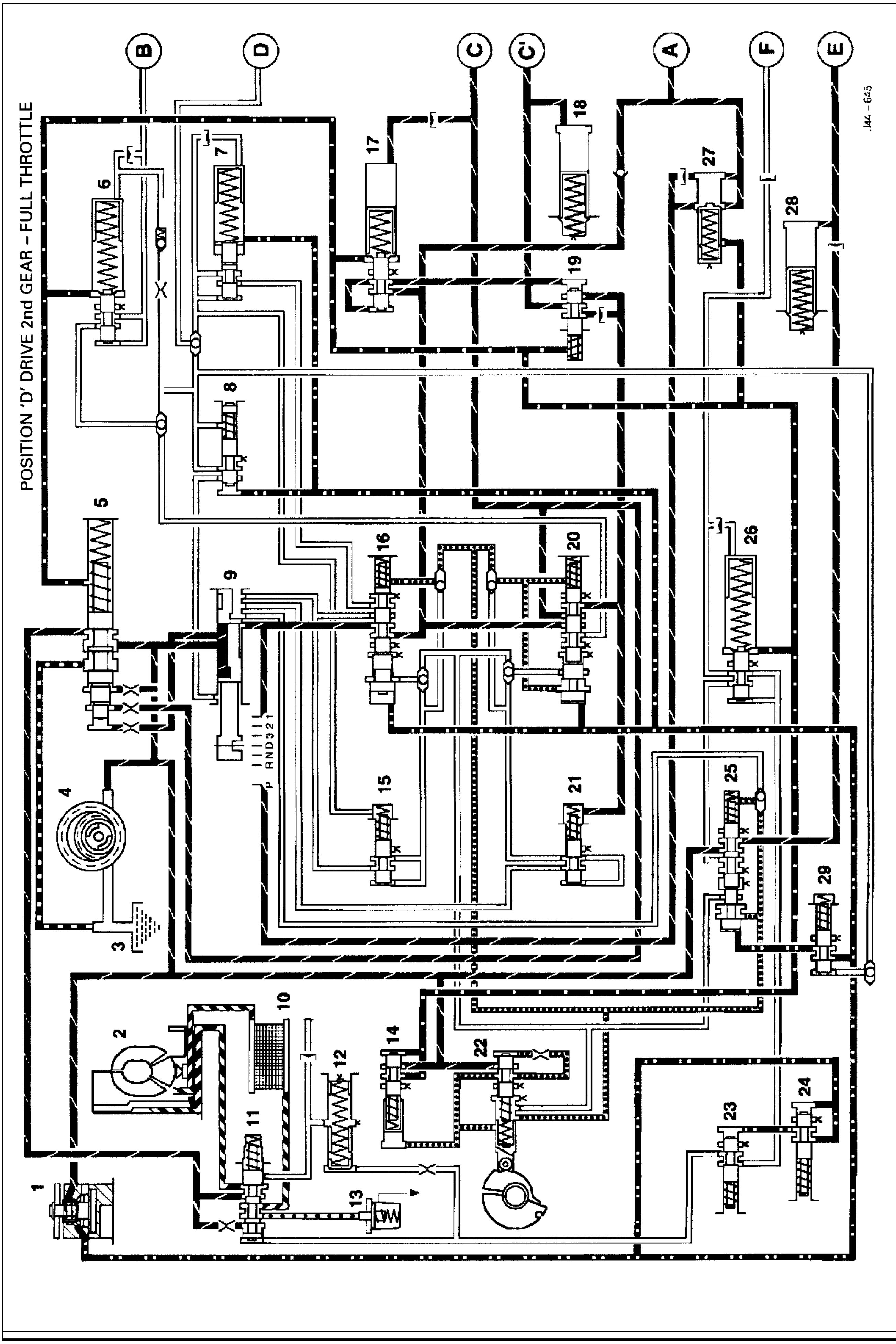

POSITION 'N' NEUTRAL
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C'
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F
E
J44-840
P R N D 3 2 1
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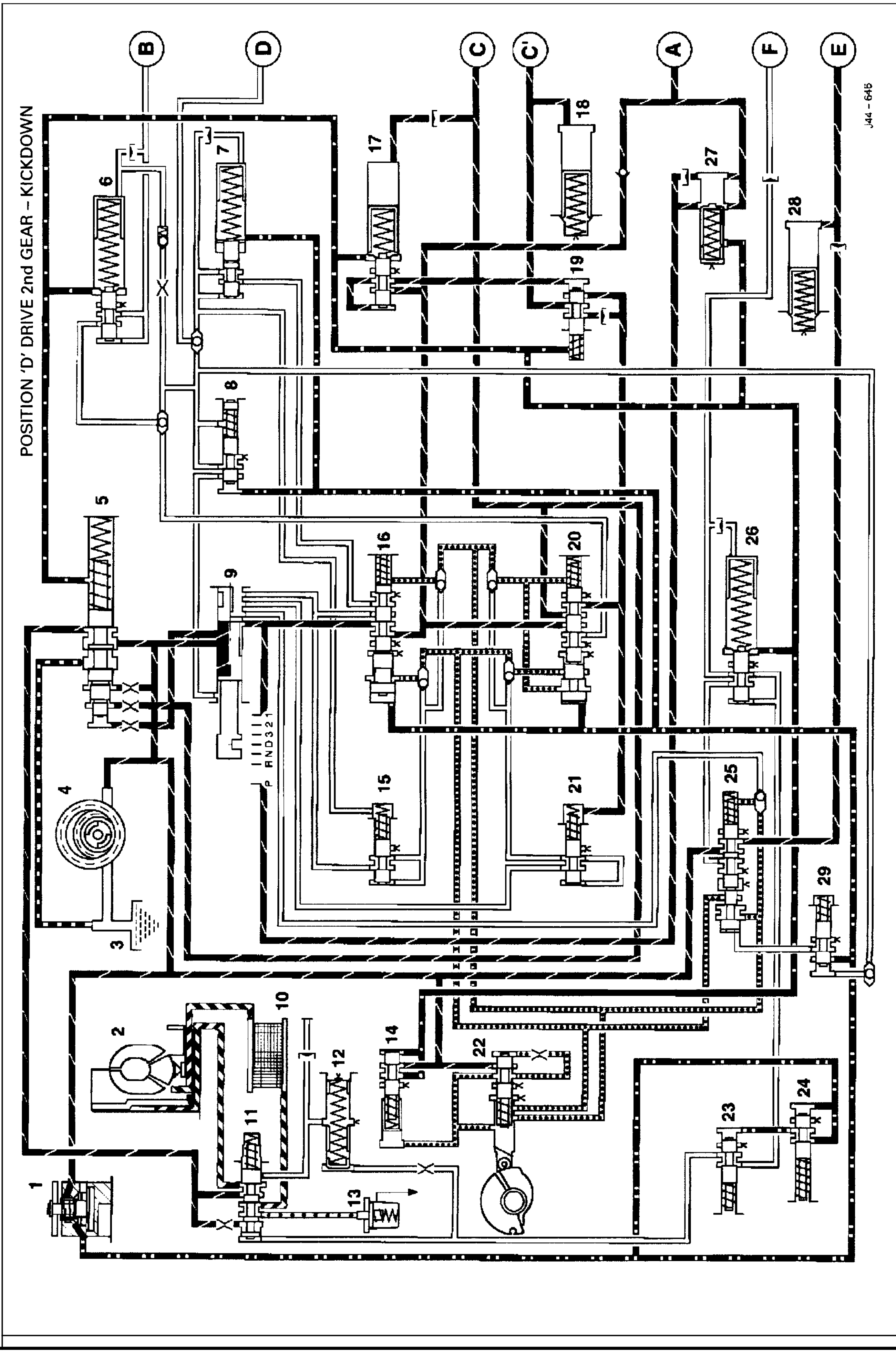

POSITION 'D' DRIVE 1st GEAR – IDLE
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D
C
C'
A
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E
J44 - 641
P R N D 3 2 1
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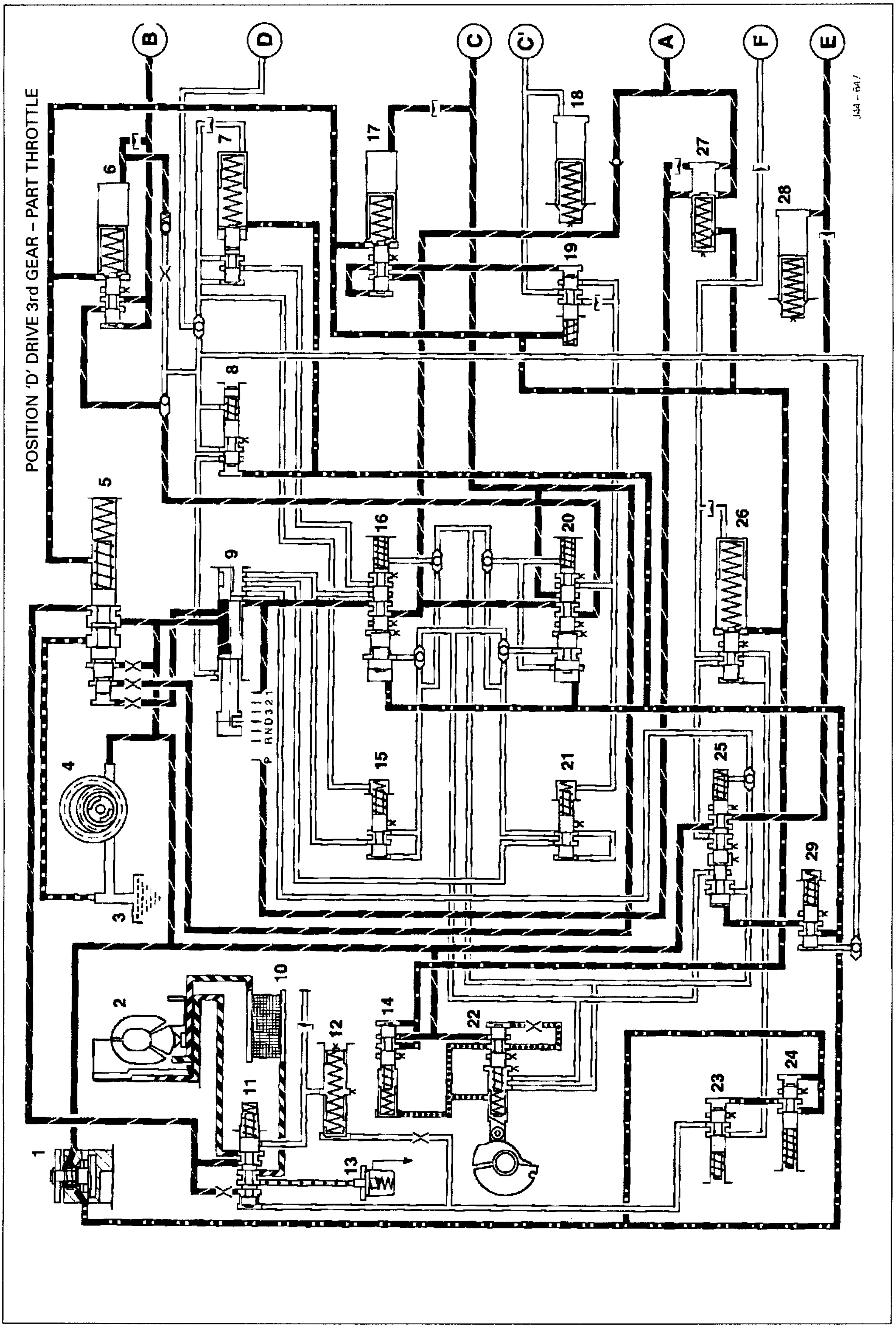

POSITION 'D' DRIVE 1st GEAR – FULL THROTTLE
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C
C'
A
F
E
J44 - 642
P R N D 3 2 1
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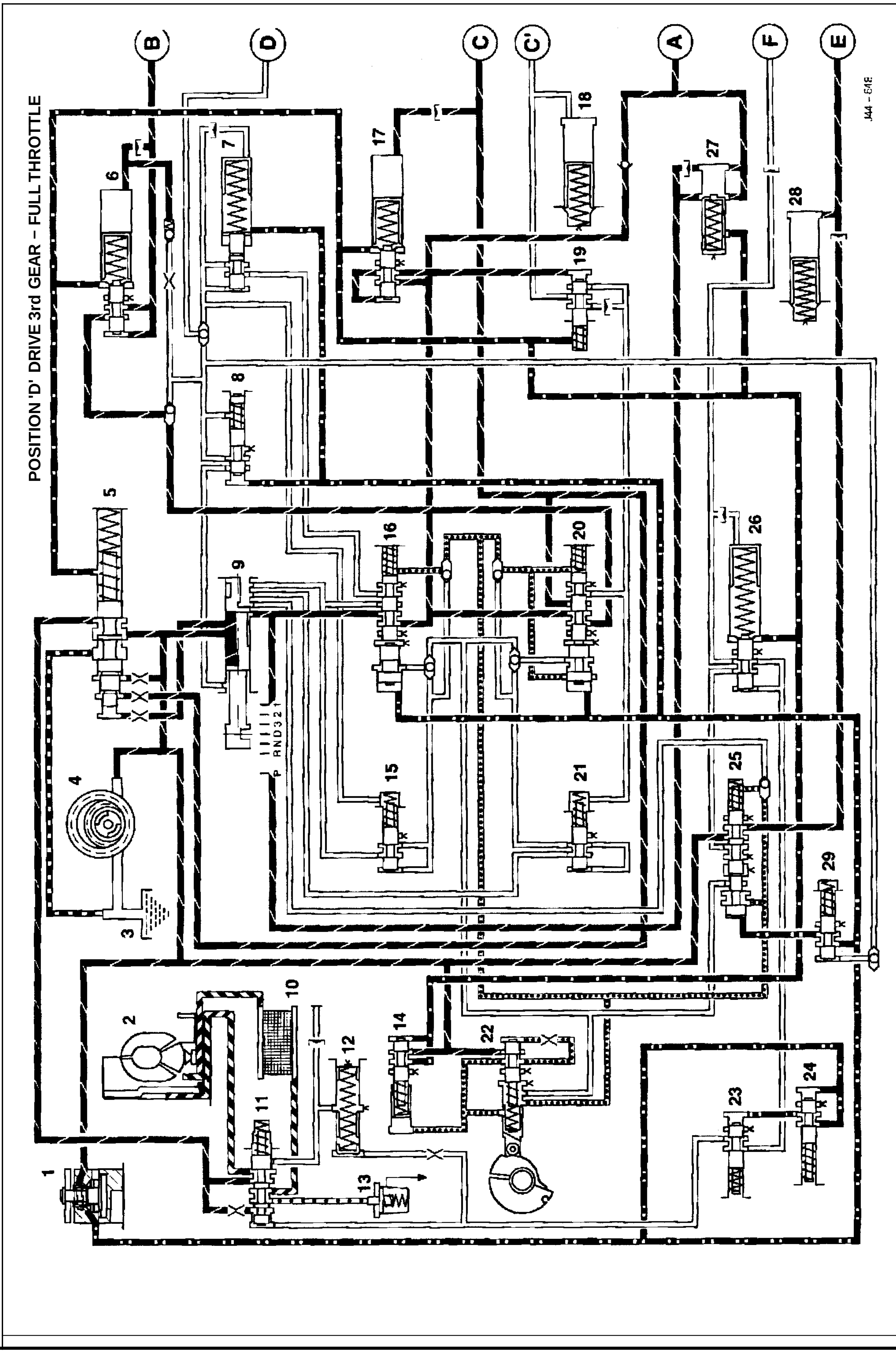

POSITION 'D' DRIVE 1st GEAR – KICKDOWN
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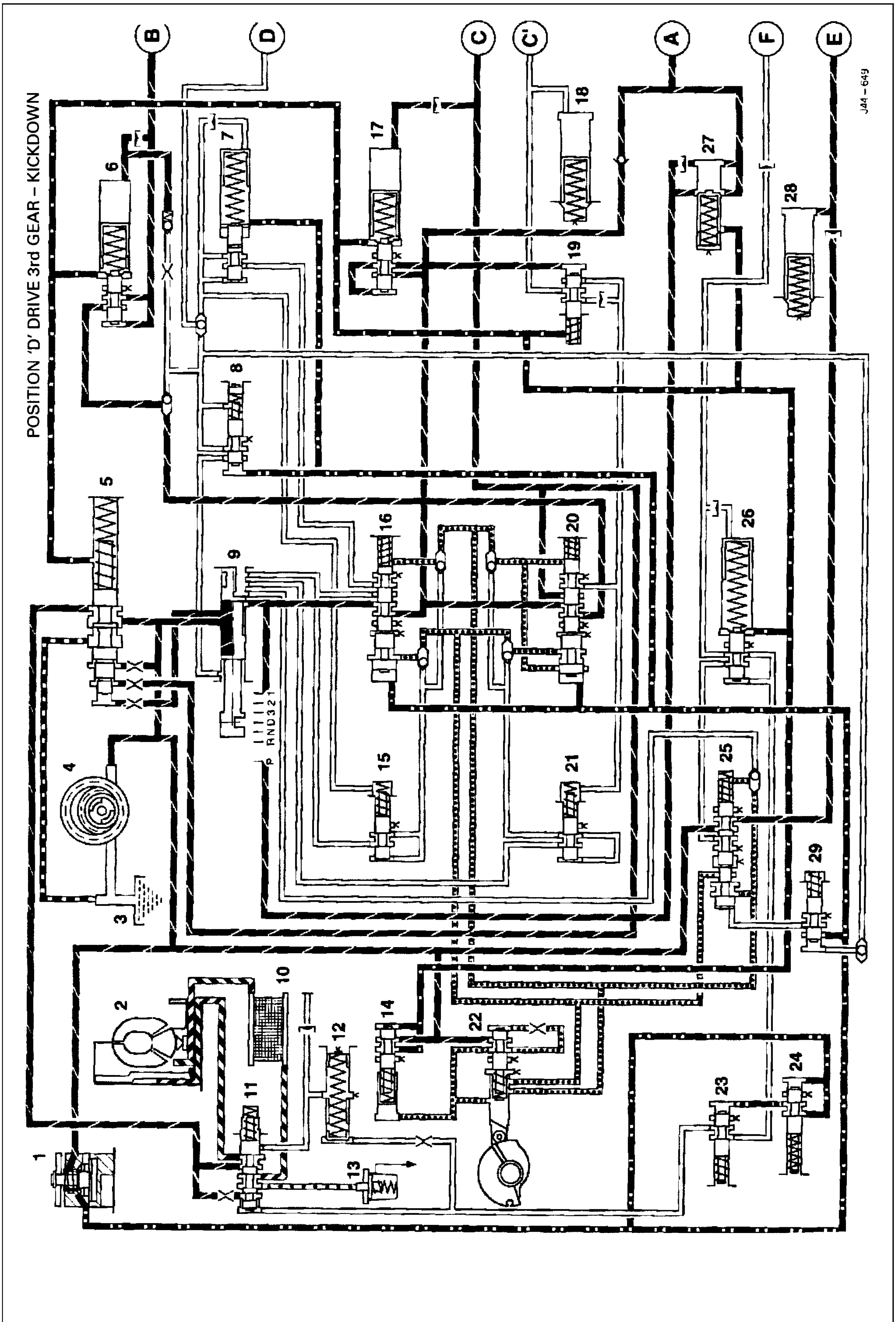

POSITION 'D' DRIVE 2nd GEAR – IDLE
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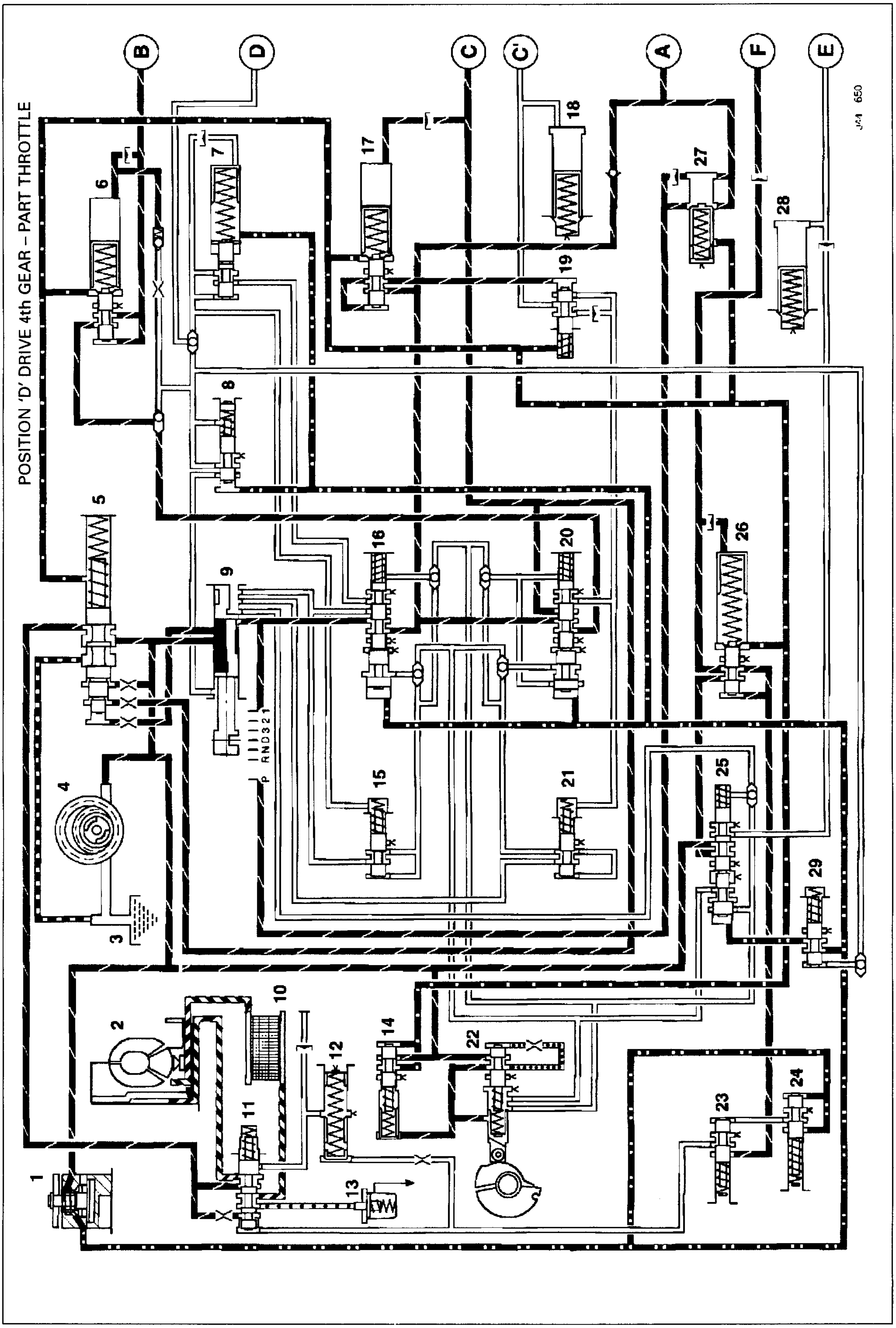

POSITION 'D' DRIVE 2nd GEAR – FULL THROTTLE
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D
C
C'
A
F
E
P R N D 3 2 1

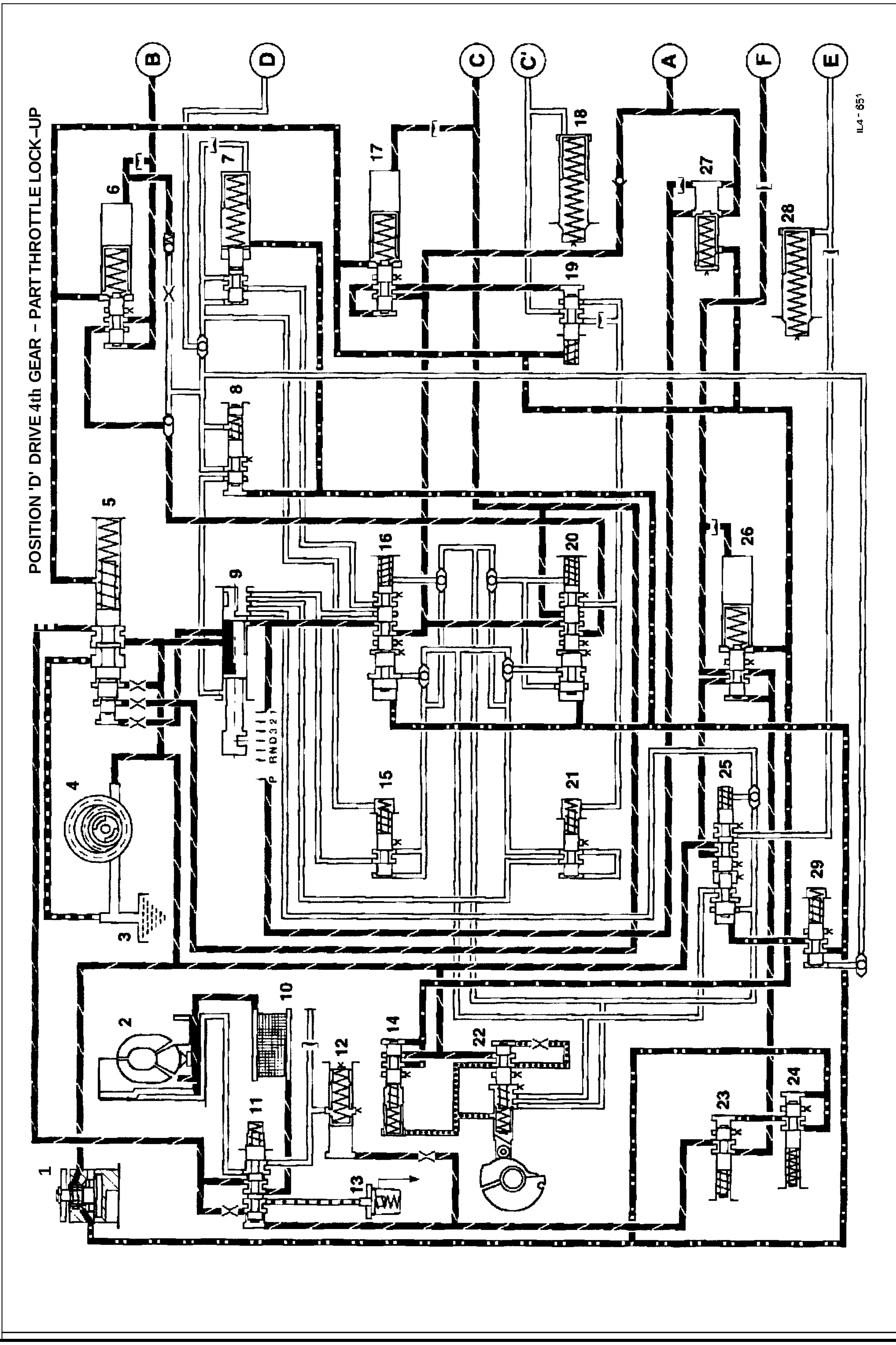

POSITION 'D' DRIVE 2nd GEAR – KICKDOWN
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J44 - 645
P R N D 3 2 1
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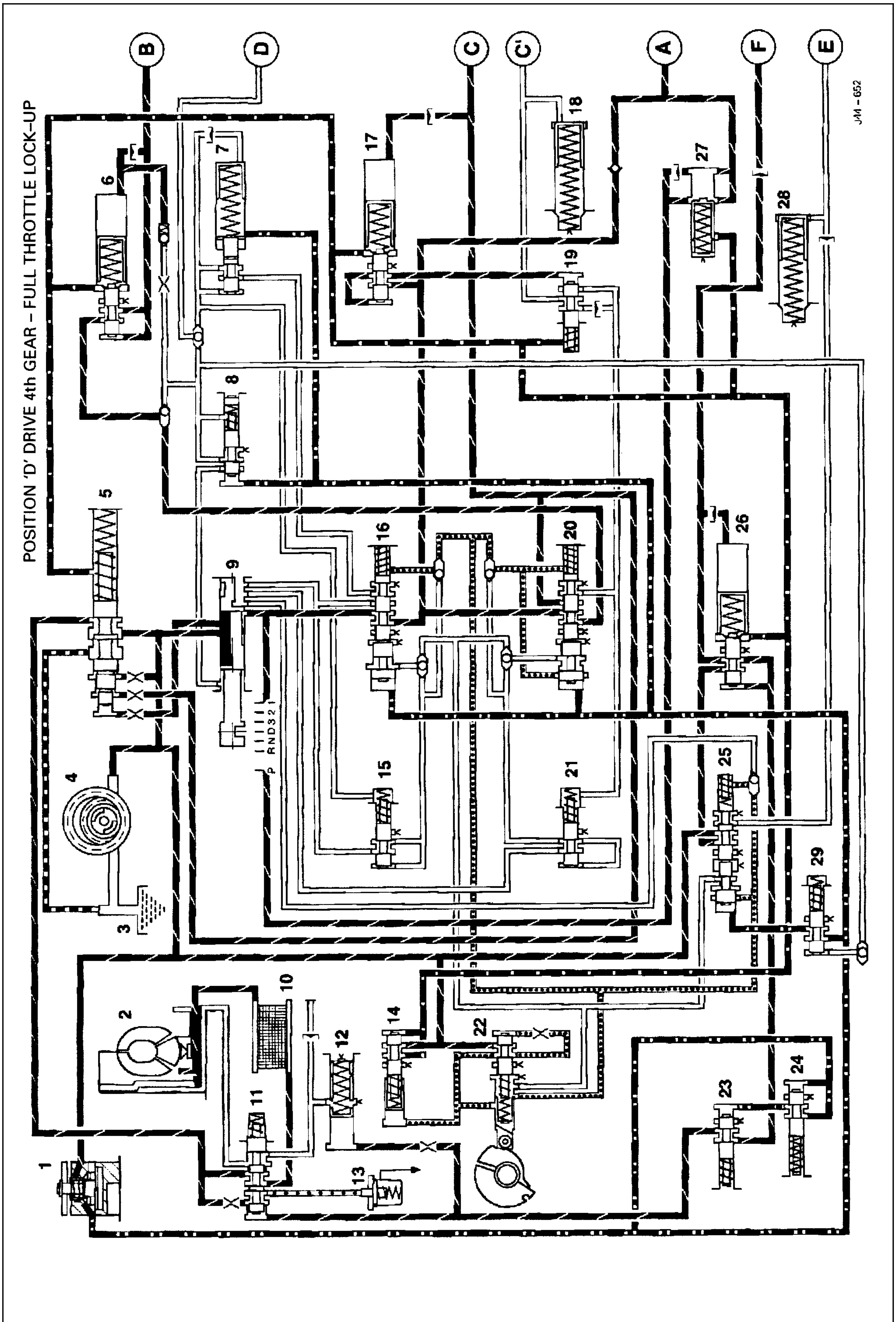

POSITION 'D' DRIVE 3rd GEAR – PART THROTTLE
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C'
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23
24
25
26
27
28
29
P R N D 3 2 1

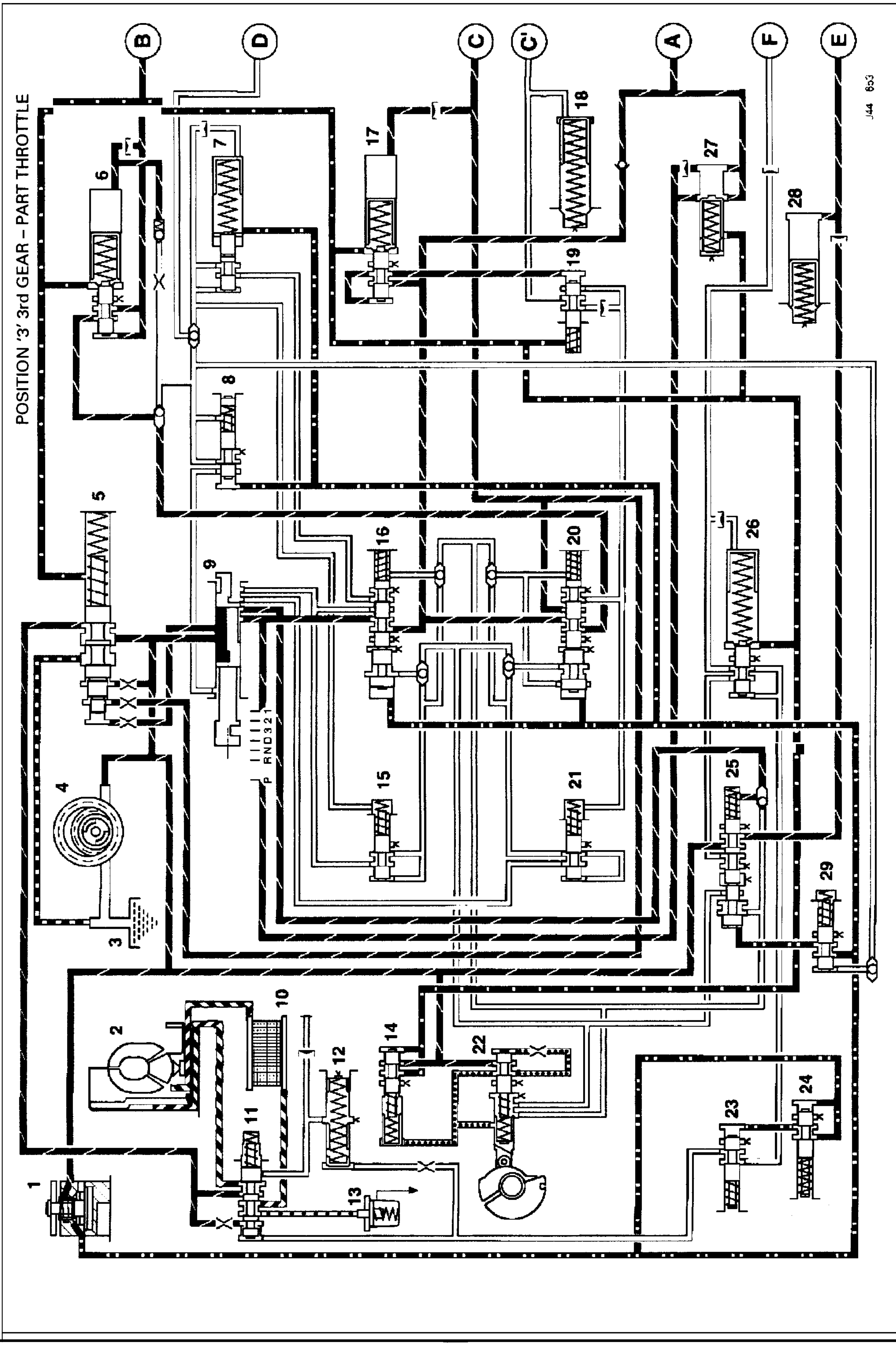

POSITION 'D' DRIVE 3rd GEAR – FULL THROTTLE
B
D
C
C'
A
F
E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
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25
26
27
28
29
P R N D 3 2 1
J44 - 648

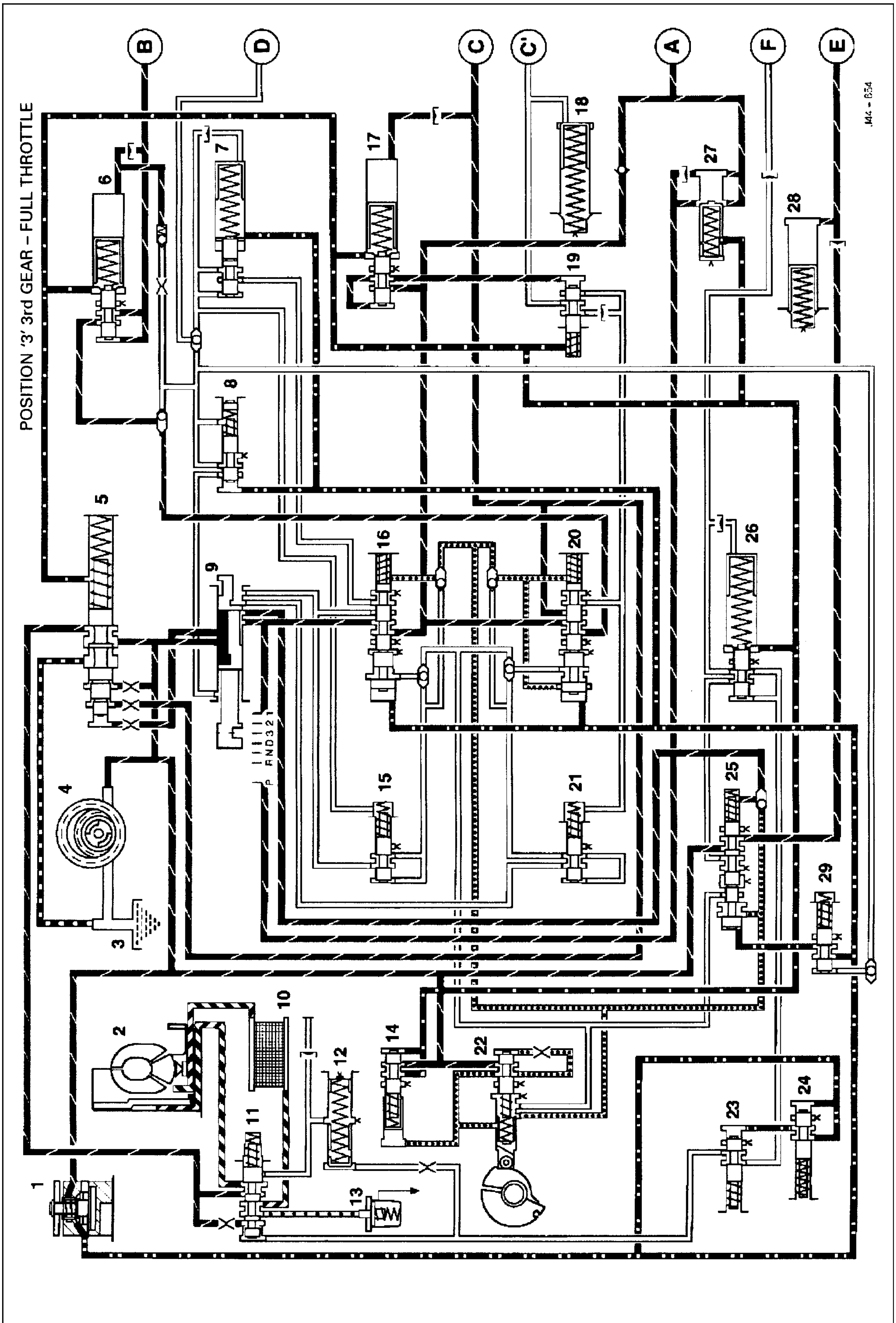

POSITION 'D' DRIVE 3rd GEAR – KICKDOWN
B
D
C
C'
A
F
E
J44 – 649
1
2
3
4
5
6
7
8
9
10
11
12
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28
29
P R N D 3 2 1

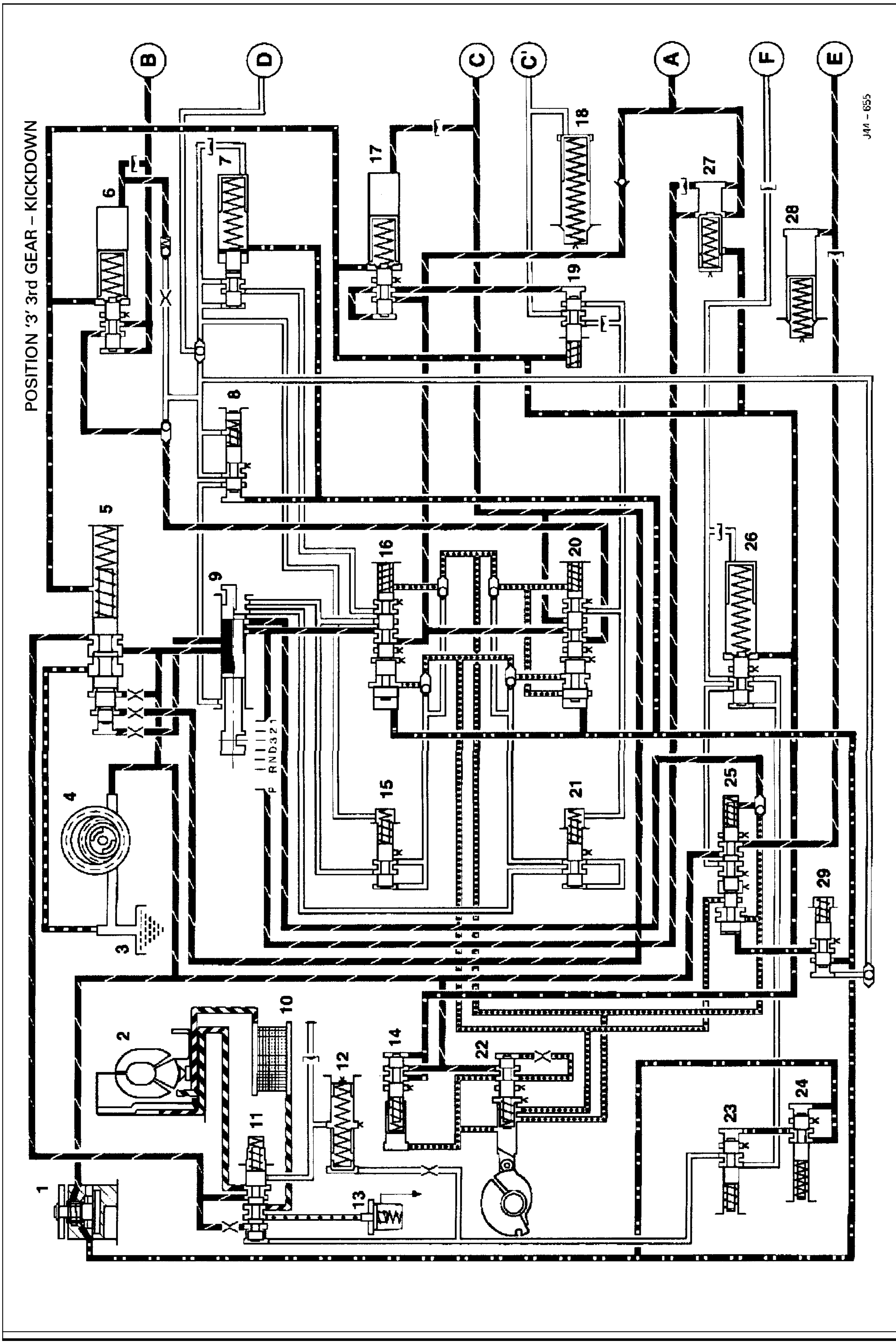

POSITION 'D' DRIVE 4th GEAR – PART THROTTLE
B
D
C
C'
A
F
E
P R N D 3 2 1
1
2
3
4
5
6
7
8
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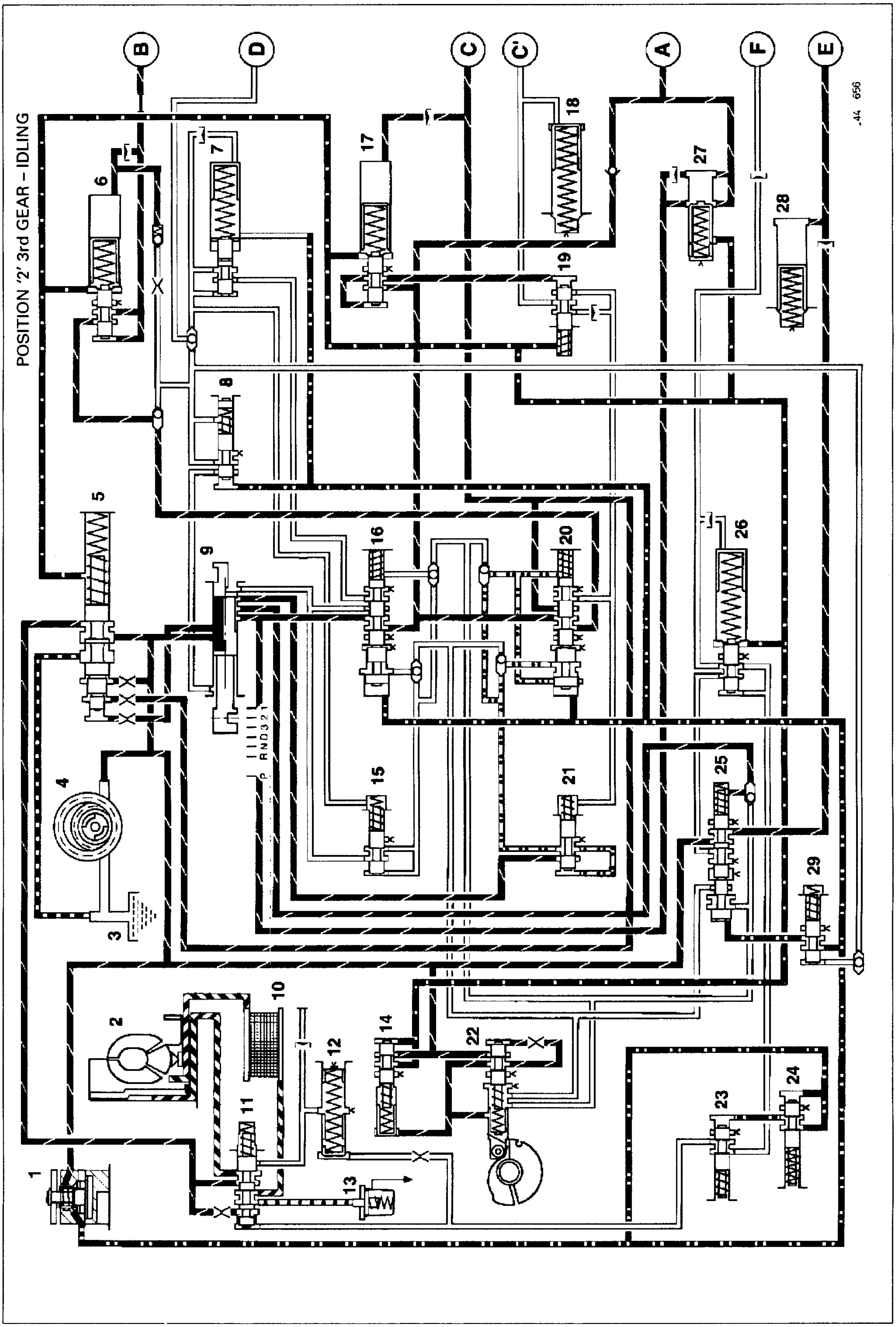

POSITION 'D' DRIVE 4th GEAR – PART THROTTLE LOCK-UP
B
D
C
C'
A
F
E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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P R N D 3 2 1
IL4-651

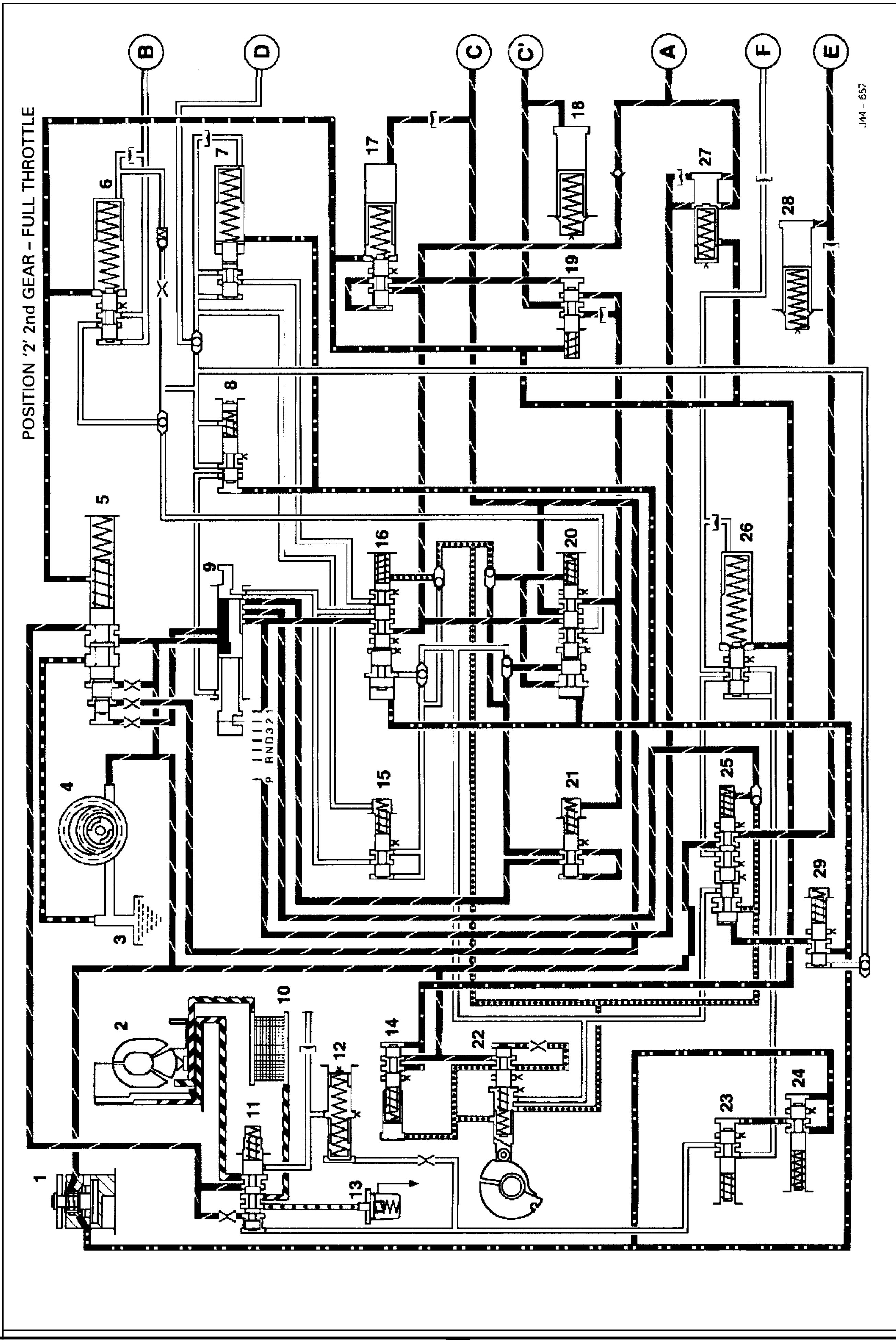

POSITION 'D' DRIVE 4th GEAR – FULL THROTTLE LOCK–UP
B
D
C
C'
A
F
E
P R N D 3 2 1
1
2
3
4
5
6
7
8
9
10
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JM - 652

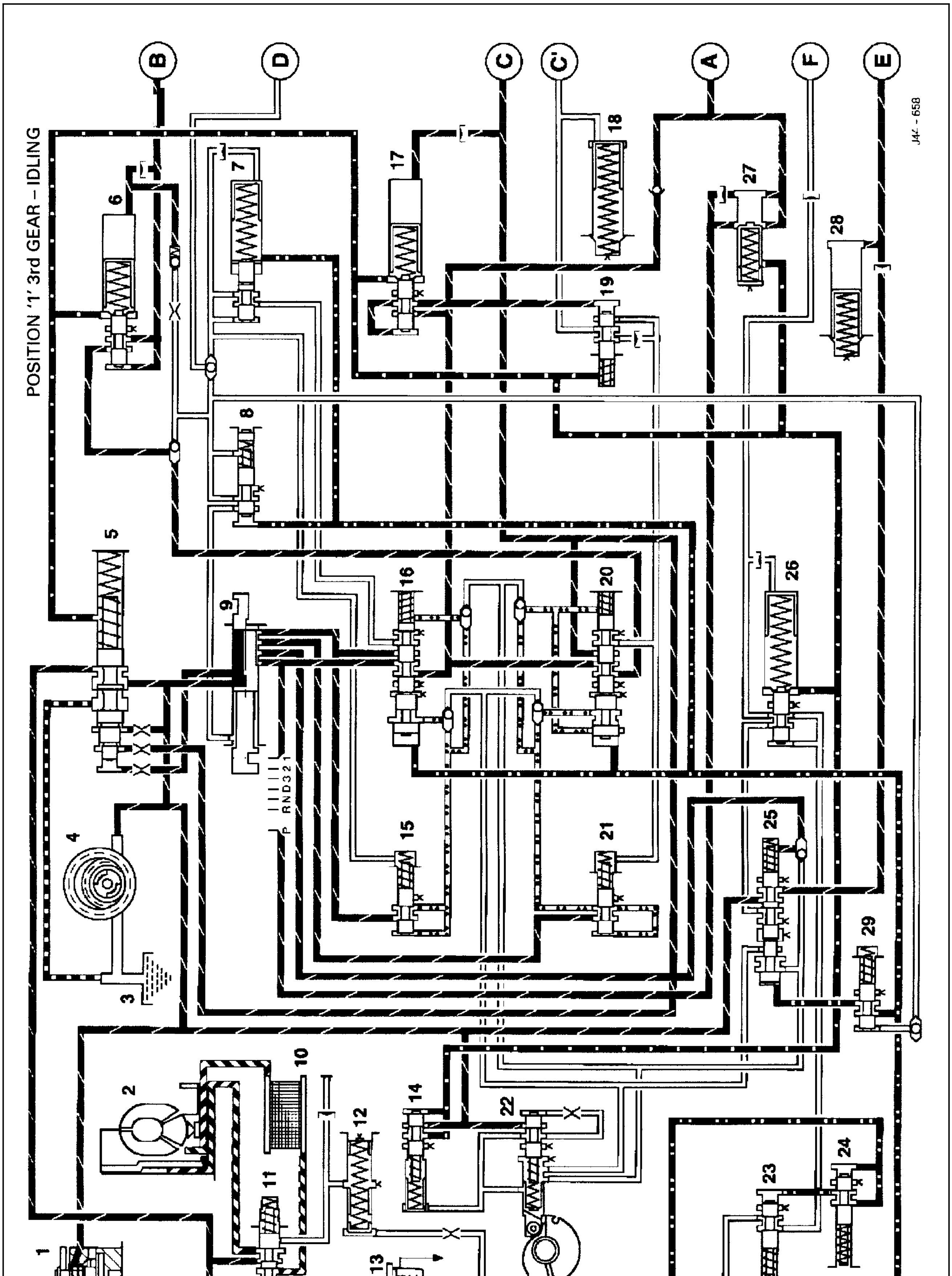

POSITION '3' 3rd GEAR – PART THROTTLE
B
D
C
C'
A
F
E
1
2
3
4
5
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7
8
9
10
11
12
13
14
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28
29
P R N D 3 2 1
J44 653

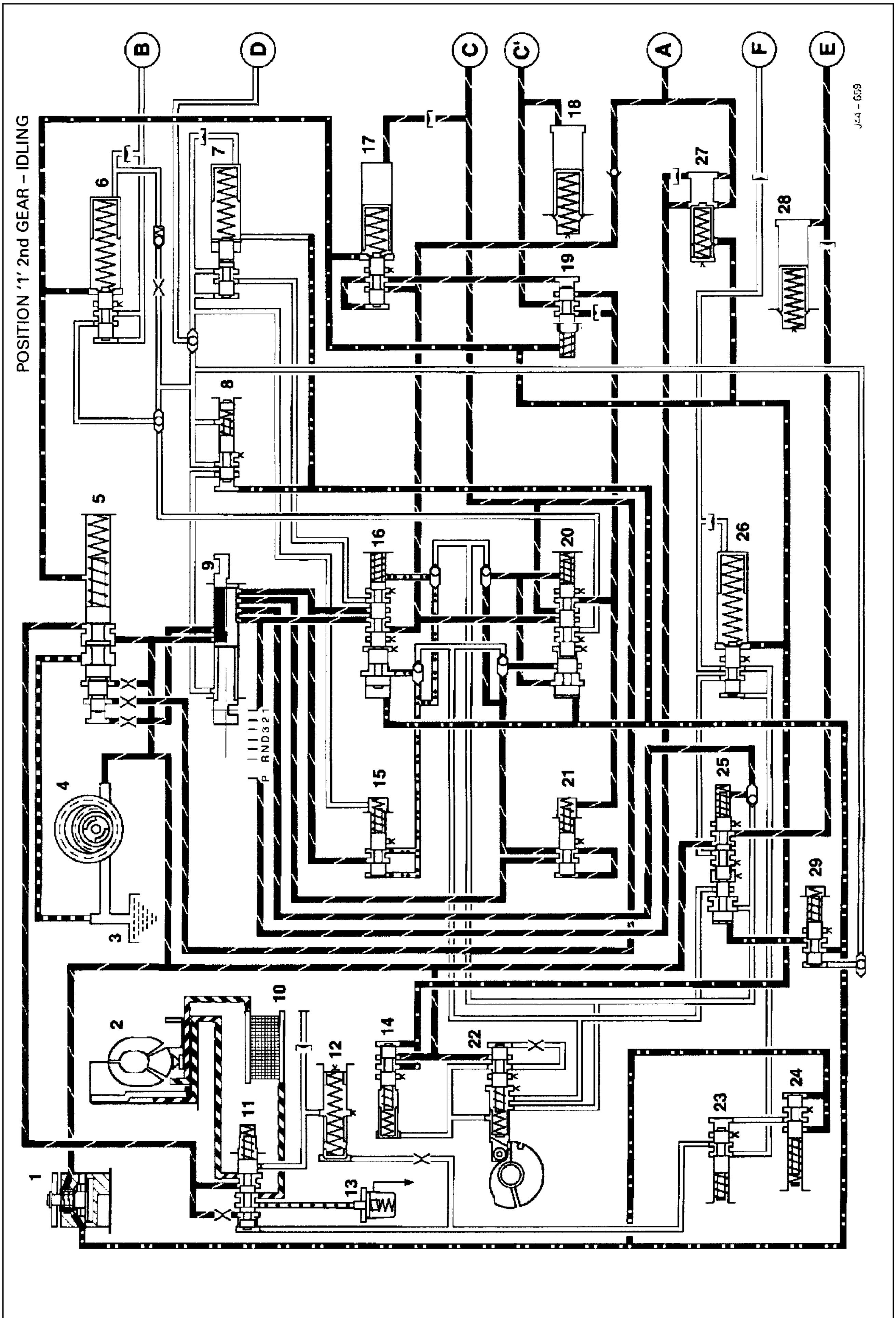

POSITION '3' 3rd GEAR – FULL THROTTLE

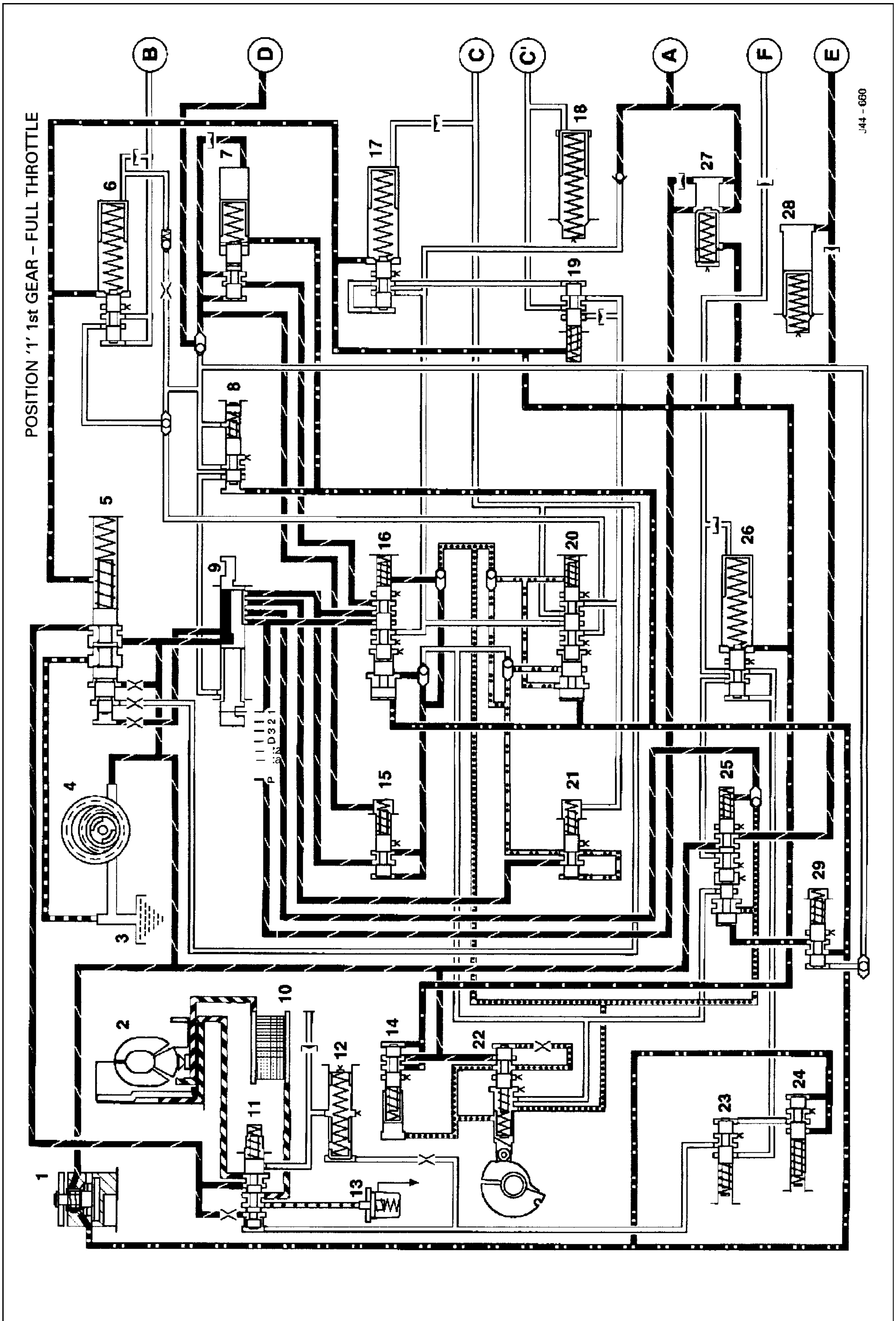

POSITION '3' 3rd GEAR – KICKDOWN
B
D
C
C'
A
F
E
J44 - 655
P R N D 3 2 1


POSITION '2' 3rd GEAR – IDLING
B
D
C
C'
A
F
E
1
2
3
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29
P R N D 3 2 1
J44 656


POSITION '2' 2nd GEAR – FULL THROTTLE
B
D
C
C'
A
F
E
1
2
3
4
5
6
7
8
9
10
11
12
13
14
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16
17
18
19
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21
22
23
24
25
26
27
28
29
P R N D 3 2 1
JM - 657


POSITION '1' 3rd GEAR – IDLING
B
D
C
C'
A
F
E
P R N D 3 2 1
1
2
3
4
5
6
7
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13
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POSITION '1' 2nd GEAR – IDLING
B
D
C
C'
A
F
E
1
2
3
4
5
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P R N D 3 2 1


POSITION '1' 1st GEAR – FULL THROTTLE
B
D
C
C'
A
F
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P R N D 3 2 1
J44 - 660

1.3 FAULT DIAGNOSIS

The following tables are intended as a guide to diaanosis of possible faults in the ZF 4 HP 22 transmission. When the fault involves a leak, it is recommended that it is located by the use of a crack detection fluid, eg Met–L–Check, which is available in spray form and permits the leak to be located after a short test drive.

1.3.1 Initial Checks

Note: Before attempting diagnosis, ensure that the following settings are checked:

Transmission oil level.

- Ensure that the transmission is at normal operating temperature, eg by conducting a road test. If starting from cold, check for presence of oil on dipstick at idle in Park before start of road test.
- Check that the vehicle is on level ground.
- Firmly apply the parking and footbrakes and run the engine at idle speed.
- To ensure that the system is primed, slowly move the selector lever through all the gear positions.
- With the engine still running, engage 'P' Park, withdraw the dipstick and wipe with a lint free cloth.
- Replace the dipstick slowly and withdraw it noting the level.
- Top up as required and recheck the level.

1.3.2 Engine Tune

Selector cable adjustment.

- Check gear selection in all selector positions.
- If in doubt, select 'N', disconnect the cable at the gearbox selector lever, check that the gearbox lever is in 'N' position (third detent from the rear) and refit the selector cable ball pin to the lever.
- Adjust as necessary, see Vehicle Service Manual.
- Kick–down switch adjustment, see Vehicle Service Manual.

1.3.3 Stall Test

- Ensure the transmission is at normal running temperature.
- Fully apply the parking brake.
- Start the engine.
- Fully depress the footbrake.
- Select position 'D'– Drive.
- Fully depress the accelerator ('kick–down' detent fully depressed).
- Note the tachometer reading.
- Compare the tachometer reading to the specification.

CAUTION: This test must not last more than 5 seconds. Always allow the engine to idle for at least 2 minutes between tests to allow the transmission fluid to cool down. Do not carry out more than three tests in any half–hour.

1.3.4 Road Test

Fully check all shift speeds and note. Compare the results with the specification in addition to general observations of transmission behaviour, noises, leaks etc., and consult the following Fault Finding Chart.

CAUTION: When renewing the transmission, ALWAYS flush out the oil cooler and feed and return pipes.

1.3.5 Electrical Checks

If any electrical component fault is suspected, refer to the Electrical Diagnostic Manual (EDM) to verify the failure mode before a repair or replacement is attempted.

1.3.6 *Fault Finding Chart*

Problem	Possible Cause	Action
Converter		
Stall speed too low	Stator freewheel faulty allowing stator to revolve	Renew torque converter
	Engine out of tune	Check engine tune.
Stall speed too high and keeps rising	Transmission slip.	Check oil level, check mechanical failure, renew transmission as necessary.
	Engine out of tune	
Acceleration below specification	Torque converter freewheel faulty allowing stator to revolve.	Renew torque converter.
	Engine out of tune.	Check engine tune.
Top speed below specification	Torque converter freewheel seized.	Renew torque converter.
	Engine out of tune.	Check engine tune.
Position 'P' – Park		
Will not move out of Park	Gearshift interlock failure	Rectify. Renew fuse, check circuits, renew relay and solenoid.
Does not engage Park	Parking pawl mechanism sticking	Renew park pawl components: connecting bar, pawl pin, tension spring, guide piece & guide sheet
	Check cable adjustment	Adjust cable as necessary.
Does not hold	Parking pawl mechanism damaged	Replace park pawl components
	Check cable adjustment	Adjust cable as necessary.
Starter motor does not operate	Starter inhibit switch faulty.	Replace switch.
	Faulty selector lever.	Replace lever.
	Position 'P' or 'N' not selected.	Select 'P' or 'N'.
	Check cable adjustment	Adjust cable as necessary.
Position 'R – Reverse		
No reverse gear or severely delayed engagement	Dirty oil filter.	Renew oil filter.
	Jammed governor.	Replace governor.
	Jammed reverse inhibit valve.	Replace valve block.
	Low oil level.	Check oil.
High pitched squeaking noise	'B' clutch destroyed (also no 3rd gear in Drive).	Service / renew transmission.
	'D' clutch destroyed.	Service / renew transmission.
	'E' clutch destroyed (no engine braking in 2nd & 3rd gears.	Service / renew transmission.
	Reverse gear safety valve faulty.	Service / renew valve block.

1.3.6 Fault Finding Chart (continued)

Problem	Possible Cause	Action
Slipping or shaking from start in reverse gear	'B','E' or 'D' clutch defective	Service / renew transmission.
Strong jerk, or distant double jerk, when engaging positions 'P–R', or 'N–R' (below 1500RPM engine speed)	Damper 'B' defective (will give the same symptoms when changing from 2nd to 3rd gears	Service / renew valve block
Reverse lamp does not illuminate (bulbs, fuses and cables functioning correctly)	Starter inhibit switch faulty. Faulty selector lever. Position 'R' not selected.	Renew switch. Renew lever. Select 'R'.
No drive or severe delay.	Dirty oil filter. Oil level incorrect. 'A' clutch defective. 'D' clutch one–way clutch faulty.	If there is no debris in sump, renew the oil filter and oil; if debris is present in the sump, renew the transmission. Check oil level. Service / renew transmission. Service / renew transmission.
Slipping or shaking during initial forward movement	'A' clutch damaged	Service / renew transmision
Strong jerk 'N–D' (below 1500 RPM engine speed)	'A' clutch faulty. 'A' clutch damper faulty.	Service / renew transmission. Service / renew valve block.
Gear change functions faulty (in cold or warm state)		
Change 1st to 2nd / 2nd to 1st	Governor dirty. Shift valve 1–2 sticking.	Renew governor. Renew valve block.
Change 1st to 2nd	Brake 'C1' and / or 'C' faulty	Service / renew transmission
Change 2nd to 3rd / 3rd to 2nd	Governor dirty. Shift valve 2–3 sticking.	Renew governor. Renew valve block.
Change 2nd to 3rd	'B' clutch faulty	Service / renew transmission
Change 3rd to 4th / 4th to 3rd	Governor dirty. Shift valve 3–4 sticking.	Renew governor. Renew valve block.
Sudden shifts	Dampers sticking	Service / renew valve block
Vehicle starts in 2nd gear	Governor sleeve sticking. Shift valve 1–2 sticking.	Renew governor. Renew valve block.
Vehicle starts in 3rd gear	Governor sleeve sticking. Shift valves 1–2 and 2–3 sticking.	Renew governor. Service / renew valve block.
Gearbox changes 1st to 3rd	Shift valve 2–3 sticking	Service / renew valve block
No shifts	Governor sticking. Dampers sticking.	Change governor. Service / renew valve block

1.3.6 Fault Finding Chart (continued)

Problem	Possible Cause	Action
No changes at light throttle setting	Dirty governor. Shift valves sticking.	Renew governor. Service / renew valve block.
Change points incorrect at full throttle setting	'Kick-down' cable setting incorrect	Adjust setting
No changes at 'kick-down' - 1st to 2nd / 2nd to 1st	'Kick-down' cable setting incorrect	Adjust setting
No changes at 'kick-down' - 2nd to 3rd / 3rd to 2nd	'Kick-down' cable setting incorrect	Adjust setting
Poor changes	Throttle valve ('kickdown') cable setting incorrect	Adjust setting
Harsh changes at low throttle	Defective damper. Modulation pressure too high. 'Kick-down' cable setting incorrect. Clutch plates damaged.	Service / renew valve block. Service / renew valve block. Adjust setting, Service / renew transmission.
Soft changes at full throttle and 'kick-down'	Defective damper. 'Kick-down' cable setting incorrect. Modulation pressure too low. Clutch plates damaged.	Service / renew valve block. Adjust setting. Service / renew valve block. Service / renew transmission.
Harsh changes at full throttle and 'kick-down'	Incorrect modulation pressure. 'Kick-down' cable setting incorrect. Defective damper.	Service / renew valve block. Adjust setting.
Manual change 3rd to 2nd faulty	Locking valve '2' sticking. Governor faulty.	Service / renew valve block / governor. Service / renew valve block / governor.
No engine braking	Brake 'C' or 'E' damaged	Service / renew transmission

1.3.6 *Fault Finding Chart (continued)*

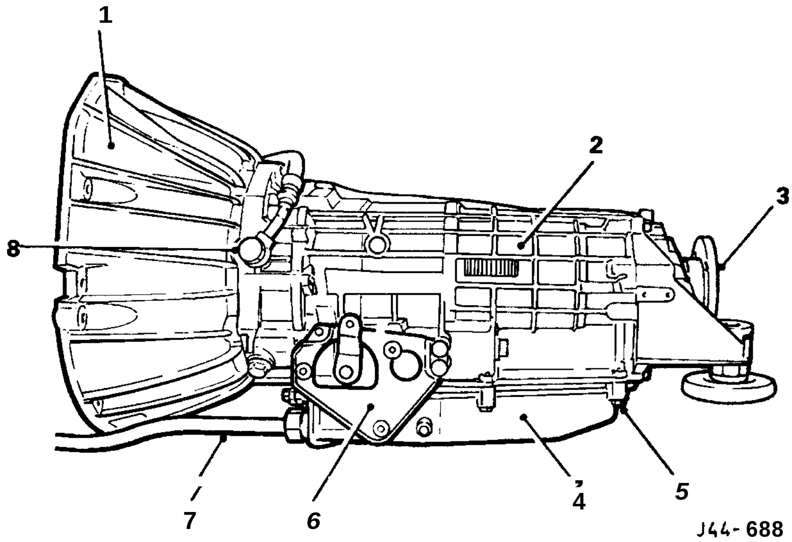
Problem	Possible Cause	Action
Change points at incorrect speeds	'Lock-up' safety valve sticking. 'Kick-down' cable setting incorrect. No 4th gear. Governor pressure incorrect.	Service / renew valve block / governor. Adjust setting. Check cable adjustment, service / renew valve block / governor. Service / renew valve block / governor.
General		
Kick-down' cable sticking	Nipple in throttle cam is worn. Too much friction in sleeve of 'kick-down' cable. Throttle pressure piston sticking.	Replace cable. Replace cable Service / renew valve block.
Noisy and no drive after a long journey	Oil filter on valve block faulty	If there is no burnt lining in the sump, renew the filter and oil. If debris is present, renew the transmission.
Very noisy and no drive	Drive plate is worn or broken	Renew the drive plate
Oil leaks		
Oil dripping from the bell housing	Seal ring in pump housing damaged. Defective pump 0-ring. Pump housing porous. Converter leaking from welded seam.	Renew seal. Renew O-ring. Renew pump housing. Renew converter.
Leakage between transmission and oil sump	Bolts incorrectly torqued. Sump gasket damaged.	Tighten bolts to specified torque. Renew sump gasket.
Leakage between intermediate plate and main housing (especially at pump pressure point)	Bell housing bolts loose. Gasket damaged.	Tighten bolts to specified torque. Renew gasket.
Oil leak at output	Output oil seal damaged	Renew seal
Leakage from cooler pipes	Loose connections. Pipes damaged. Cooler leaks.	Tighten connections. Renew pipes. Renew cooler.
Leakage between main housing and tail housing	Loose bolts. Gasket damaged.	Tighten bolts. Renew gasket.
Oil leak from 'kick-down' cable at transmission end	'O' ring connection damaged	Renew 'O' ring or complete cable

1.3.6 *Fault Finding Chart (continued)*

Problem	Possible Cause	Action
Loss of oil through breather	Oil level too high.	Check level.
	Incorrect oil.	Remove transmission, ensuring that it is drained (including torque converter, oil cooler and pipes).
	Breather blocked.	Change breather, check for foul condition of foam insulation pad.
	No breather cap.	Fit cap or renew breather.
	'O' ring breather damaged.	Remove tail housing and replace 'O' ring.
	Securing clip faulty.	Renew clip.
Oil leak at intermediate plate	Blanking plug loose	Tighten plugs. Renew sealing washers.
Leakage between gearbox and extension housing	Fastening screws loose.	Tighten screws to specified torque.
	Gasket faulty.	Renew gasket.
Noises		
High pitched squeaking noise, dependant on engine RPM, in all gears, when oil is warm and accompanied by intermittent drive after a long journey	Dirty filter	If there is no debris in the sump, renew the filter and oil. If debris is present, renew the transmission.
High pitched noise in all positions, especially if oil is cold. Sucking noise from pump.	Low oil level.	Top-up as necessary.
	Filter not sealing.	Check / renew 0-ring.
	Leaking valve block.	Service / renew valve block.
	Filter damaged.	Check filter.
Very noisy in 'lock-up'	Torsion damper faulty	Renew torque converter
Torsional vibrations from engine when in 'lock-up'	Engine RPM is too low, 'lock-up' shift point incorrect	Service / renew valve block
Loud noise when converter clutch engages	Torsion damper defective	Renew converter
Engine vibrations when converter clutch engaged	Change point too low	Check valve block

2.1 ZF 4 HP 24 E TRANSMISSION, GENERAL DESCRIPTION

The ZF Transmission covered in this section comprises a hydrodynamic torque converter, four speed gear train and electronic–hydraulic transmission control unit.



1. Torque converter
2. 4–speed gear train
3. Output flange
4. Transmission control unit
5. Oil outlet (drain plug)
6. Rotary switch positions (see text)
7. Dipstick/ oil filler tube
8. Oil cooler connection

Fig. 1 ZF 4 HP 24 E Transmission

The automatic transmission provides six gearshift positions:

- Position 'P': Park – in this position the driven wheels are mechanically locked at the transmission.
- Position 'R': Reverse – reverse gear selected.
- Position 'N': Neutral – engine disconnected from drive–line and wheels.
- Position 'D': Drive – all four speed ranges are selected automatically with lock–up available in top gear only.
- Position **'3':** automatic selection of the lowest three speed ranges only.
- Position **'2':** automatic selection of the lowest two speed ranges only, transmission is prevented from shifting up to the third and top speed ranges.

Immediate selection of a lower ratio is also available by 'kick–down' (pressing the accelerator down beyond the normal full throttle position) for example when overtaking.

2.1.1 Torque Converter

The torque converter serves two main functions: it acts as a fluid coupling between engine and transmission geartrain and it provides multiplication of engine torque when required.

The torque converter consists of an impeller, a turbine and a stator which is mounted on a one–way clutch. The converter cover is fixed to the impeller to seal the three elements within a common housing forming a closed circuit through which oil flows when the transmission is in operation. The impeller is therefore connected to the engine and rotates at engine speed when the engine is operating.

Torque multiplication is at its greatest when the vehicle is driven away from standstill. The stator bears against the housing through its one-way clutch and deflects the oil so that the flow is accelerated. As road speed builds up, the impeller and turbine wheels turn at almost the same speed, so that the stator ceases to accelerate the oil flow and instead is disengaged from the housing and turns freely in the flow of oil. At this stage, the torque converter acts as a fluid coupling.

The torque converter acts in all four forward gears and in reverse. The converter lock–up clutch closes in 4th gear at a point depending on road speed and accelerator position; engine power is then transmitted by purely mechanical means.

A low–loss oil pump in the front of the transmission housing supplies the converter, the automatic gear shift and the lubrication circuit; oil is drawn from a sump in the bottom of the gear train housing through a filter. The pump drive gear is keyed to the converter impeller hub and therefore turns when the engine is running, thereby pressurizing the oil.

2.1.2 Four–speed Epicyclic Gear Train

The torque converter drives a mechanical epicyclic gear train providing four forward ratios and reverse. Individual ratios are obtained by coupling together the various parts of the gear train by means of solenoid–operated, hydraulically actuated multi–disc clutches and brakes; built in freewheels permit gear shifts without any interruption of the power flow.

For information on the operation of the solenoids, clutches, brakes and freewheels, refer to the table below and the schematic diagrams shown overleaf.

A parking lock pawl is provided at the rear of the gear train, operating on a toothed wheel attached to the output shaft; the parking lock is operated from the selector (position 'P') by actuator rod.

An electro–magnetic sensor detects output shaft revolutions by means of a toothed disc attached to the shaft; one revolution of the shaft is equal to 36 pulses. The electrical signal from the sensor is passed, via a screened cable, to the TCM.

Selected ratios	Solenoid	Resulting clutch operation
D_1, 3_1, 2_1	MV2	A Clutch drives annulus clockwise D Clutch OWC holds F carrier against shaft clockwise E Clutch & OWC drives output shaft clockwise
D_2, 3_2, 2_2, 1_2	MV1, MV2	A Clutch drives annulus clockwise C1 Clutch holds sungear against anti–clockwise C Clutch & OWC holds sungear against anti–clockwise
D_3, 3_3, 2_3,	MV1, MV3	A Clutch drives annulus clockwise B Clutch drives sungear clockwise C Clutch & OWC holds sungear against anti–clockwise
D_4	MV2	A Clutch drives annulus clockwise B Clutch drives sungear clockwise C Clutch & OWC holds sungear against anti–clockwise
R	–	B Clutch drives sungear clockwise D Clutch holds carrier against clockwise E Clutch & OWC drives output shaft anti–clockwise
Park, Neutral	MV2	E Clutch & OWC applied (hydraulics)

OWC = one way clutch

2.1.3 Operation Of Gear Train Clutches

Operation of the gear train clutches to provide the five gear ratios is as follows:

1st Gear

Clutches 'A' and 'E' are engaged.

The front planet gear carrier of gear set '9' is locked against the housing of through freewheel '10' when the engine is pulling, but is over-run when the engine is coasting.

Epicyclic gear set '10' rotates as a solid block with the second planet set.

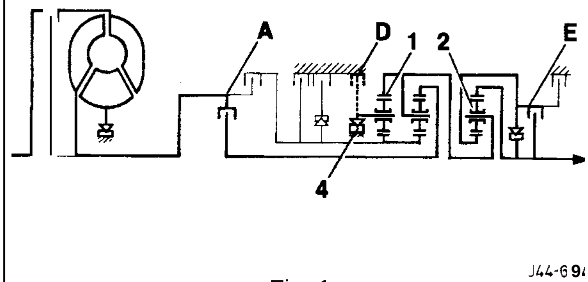


Fig. 1

2nd Gear

Clutches 'A','C1','C' and 'E' are engaged.

Freewheel '15' over-runs.

Clutches 'C1' and 'C' lock the sun gear to the housing.

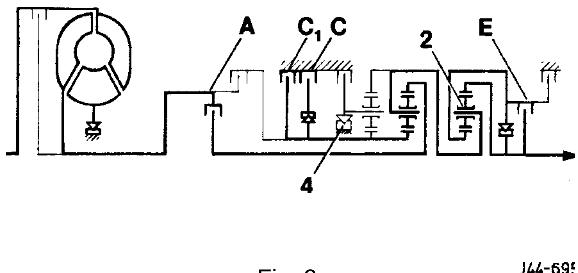


Fig. 2

3rd Gear

Clutches 'A','B','C' and 'E' are engaged.

Freewheels '14' and '15' are over-run.

Epicyclic gear sets '9' and '10' rotate as a solid block at a ratio of 1:1.

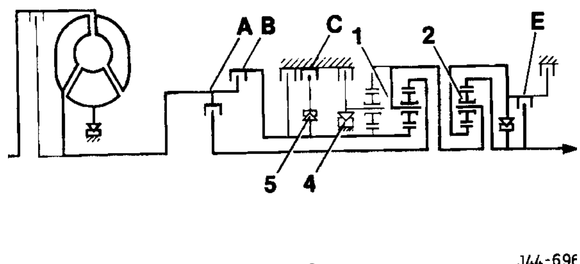


Fig. 3

4th Gear

Clutches 'A','B','C' and 'F' are engaged.

Freewheels '14','15' and '16' are over-run.

Epicyclic gear set '9' rotates as a solid block.

The hollow shaft with the sun wheel of epicyclic gear set '10' is locked.

Above a predetermined road speed, lock-up clutch '2' locks torque converter '3' solid to prevent slip.

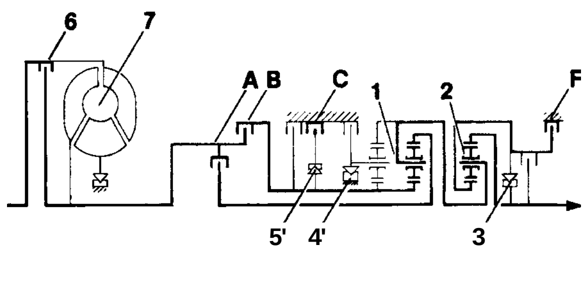


Fig. 4

Reverse Gear

Clutches 'B','D' and 'E' are engaged.

As the front planet gear carrier of epicyclic gear SE '9' is locked, the direction of output shafgt rotation is reversed.

Epicyclic gear set '10' also rotates as a solid block.

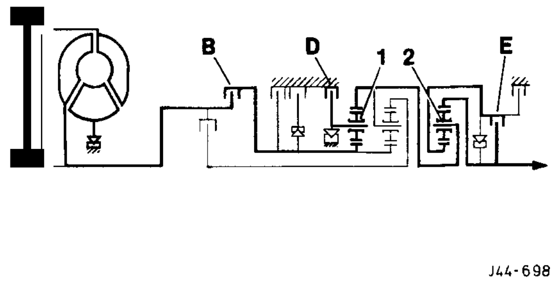


Fig. 1

2.1.4 Transmission Control Unit

The electronic–hydraulic control unit comprising a series of valve blocks housing a cable–operated manual valve, control pistons and pressure valves is attached to the underside of the transmission housing; the unit controls the operation of the gear train clutches and directs oil pressure to the appropriate system components (refer to illustrations, pages 43 to 46) to operate the transmission.

The four valve blocks in which the control valves, pistons etc are located, are mounted and connected through a main gallery plate. The three solenoid valves MV1, MV2 and MV3 and the pressure regulator operating solenoid are located on the upper surface of the plate; electrical connections between the solenoids and the transmission and transmission control unit are via cable harnesses (refer to relevant diagrams and tables for details of the various pin connections).

Operation of the transmission control unit is through an electronic Transmission Control Module (TCM) which on receipt of electrical signals from transmission and engine management sources, activates the hydraulic pressure regulating and shift valves via solenoid valves located on the valve block. The gearshift selector transmits movement, via the selector cable, to the selector lever on the side of the gearbox; this rotates the selector shaft which controls the manual selector valve. The rotary position of the shaft is monitored by the rotary switch.

2.1.6 Transmission Rotary Switch

This switch is located on a square extension of the transmission selector shaft and is linked to the shift lever via the selector cable. The switch comprises a selector bar which moves across a series of copper segments located on the switch quadrant. The copper segments are set out in seven bands, each band providing an electrical output or combination of outputs to the TCM.

The electrical outputs to the TCM are in the form of a three-digit code which takes up three of the seven bands of the quadrant; the remaining four bands are used for reverse, ground and start inhibit.

2.1.7 Decoder Module

The decoder module, located on the right hand side of the J-gate assembly, is used to translate the three-digit codes from the rotary transmission switch into single-line functions to feed the illumination module and to provide the following information:

- Cruise control, ie when cruise control can or cannot be engaged.
- Indication when the vehicle is not in 'P' Park.
- Provide the ECM with a Park/ Neutral signal.

2.1.8 Performance Mode Switch

This switch, located on the shift lever surround, provides two alternative shift patterns:

- 'Normal Mode' - for everyday use,
- 'Sport Mode' - gear changes take place at higher road speeds in order to enhance performance.

Note: Torque converter 'lock-up' occurs in fourth gear in each mode.

2.1.9 'Kick-down' Mechanism

'Kick-down' is activated by the final travel of the accelerator pedal which contacts a floor-mounted switch located behind the pedal. Operation of the switch provides a signal to the TCM that a downward change is required. The switch is adjustable to ensure that the pedal does not overtravel and stretch the cable.

2.1.10 Reverse Safefy Inhibit

If 'R' Reverse is selected when the vehicle is travelling forwards at more than 5 mile / h, solenoid valve MV2 will be energised to prevent engagement of reverse gear.

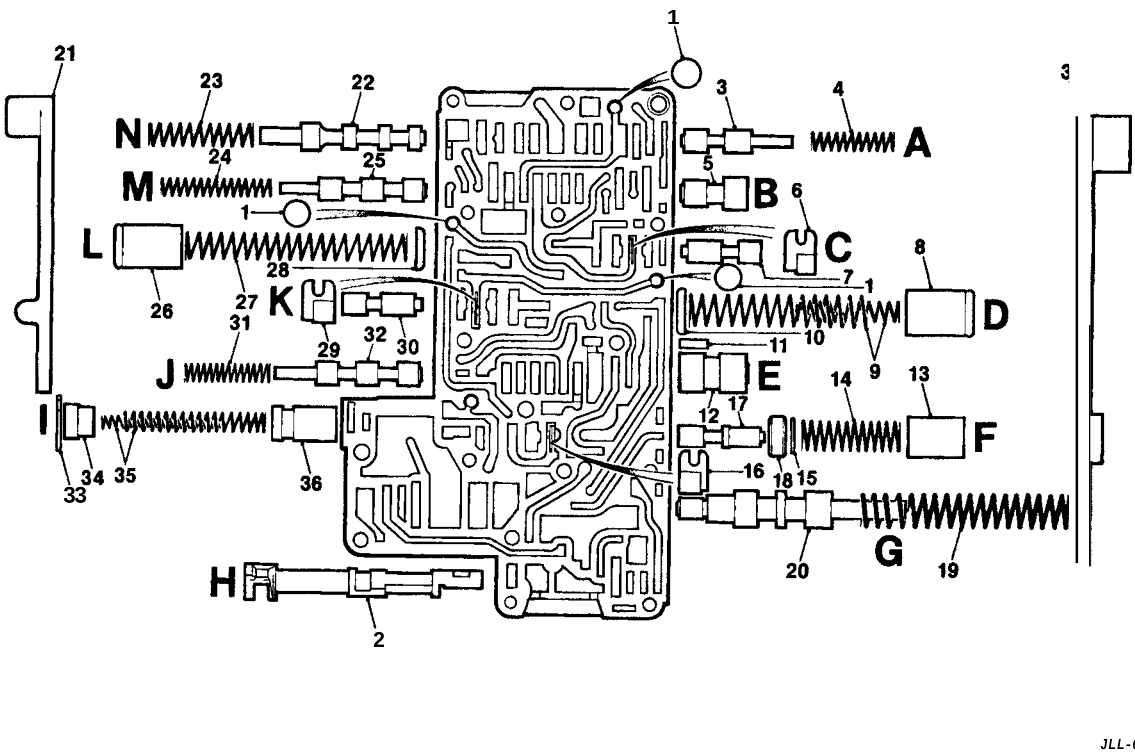
2.1.11 Gearshift Interlock

A brake pedal /gearshift interlock is incorporated in the gear selector mechanism. The gear selector lever may only be moved from the P - Park position if the ignition key switch is in position II and the foot brake is applied.

The ignition key cannot be removed from the ignition switch unless the shift lever is in the 'P' - Park position. Once the ignition key has been removed, the shift lever is locked in the park position.

2.1.12 Starter Inhibit Switch

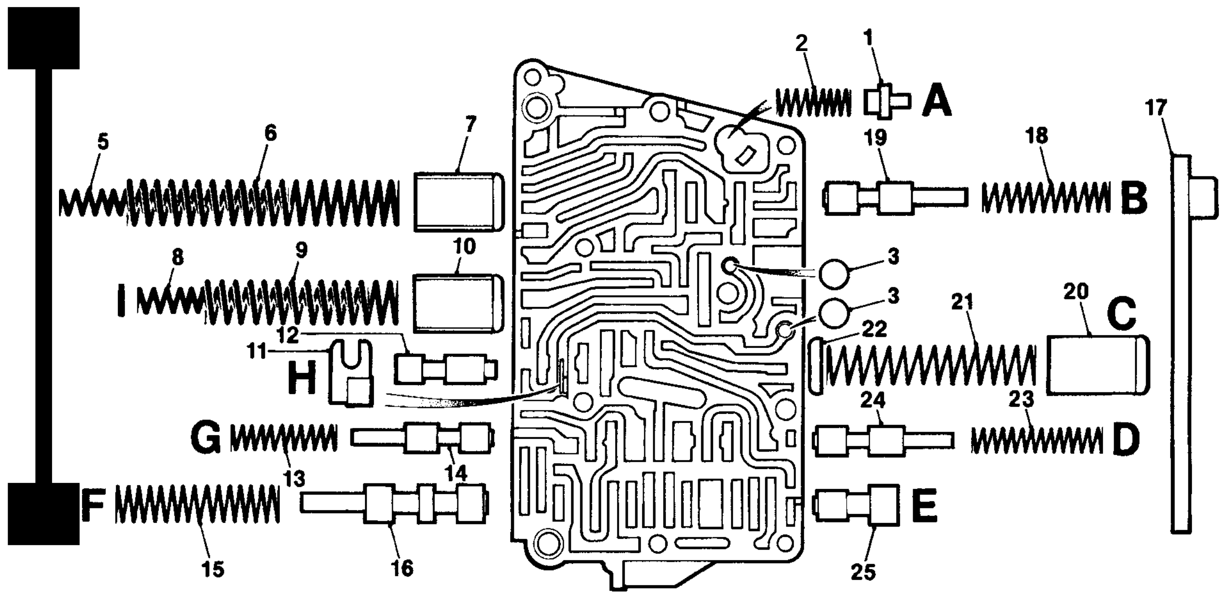
The starter inhibit switch prevents the starter motor from being operated when the shift lever is not in position 'P' - Park or position 'N' - Neutral. The switch is located in the gear selector housing.



A. C1 Clutch valve
B. 2–3 shift valve piston
C. C clutch damper valve
D. B clutch damper
E. 1–2 shift valve piston
F. D clutch valve and piston
G. Pressure regulating valve
H. Manual (selector) valve
I. A clutch damper
J. 1–2 shift valve
K. B clutch damper valve
L. C clutch damper
M. 2–3 shift valve
N. Converter pressure valve

Note: Numerical annotations are not used in this application.

Fig. 1 Manual Valve Block

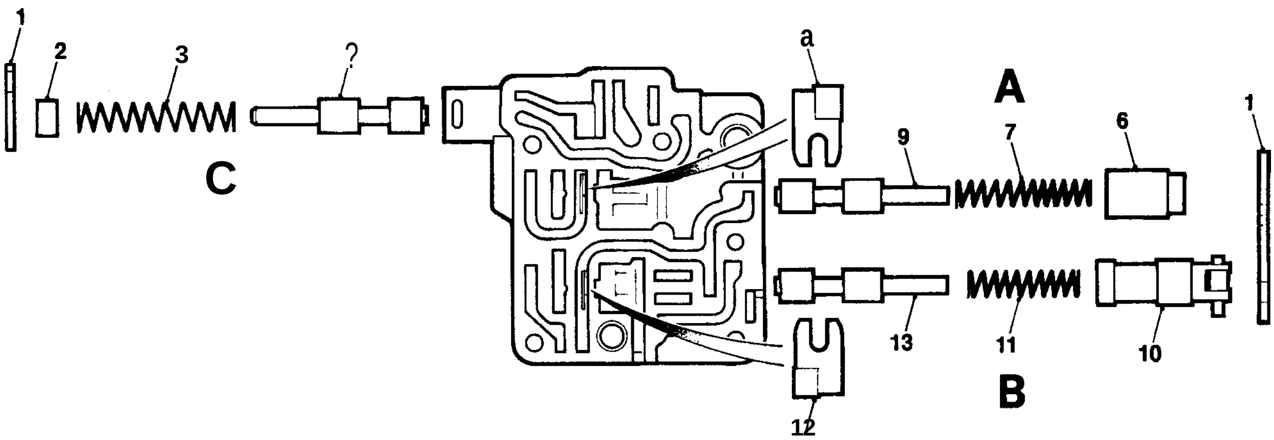


J4 70

A. One way valve (lubrication)
B. 2nd gear inhibit valve
C. F clutch damper
D. F clutch inhibit valve (reverse)
E. 3–4 shift valve piston
F. 3–4 shift valve
G. 1st gear inhibit valve
H. F clutch valve
I. E clutch damper
J. C1 clutch damper

Note: Numerical annotations are not used in this application.

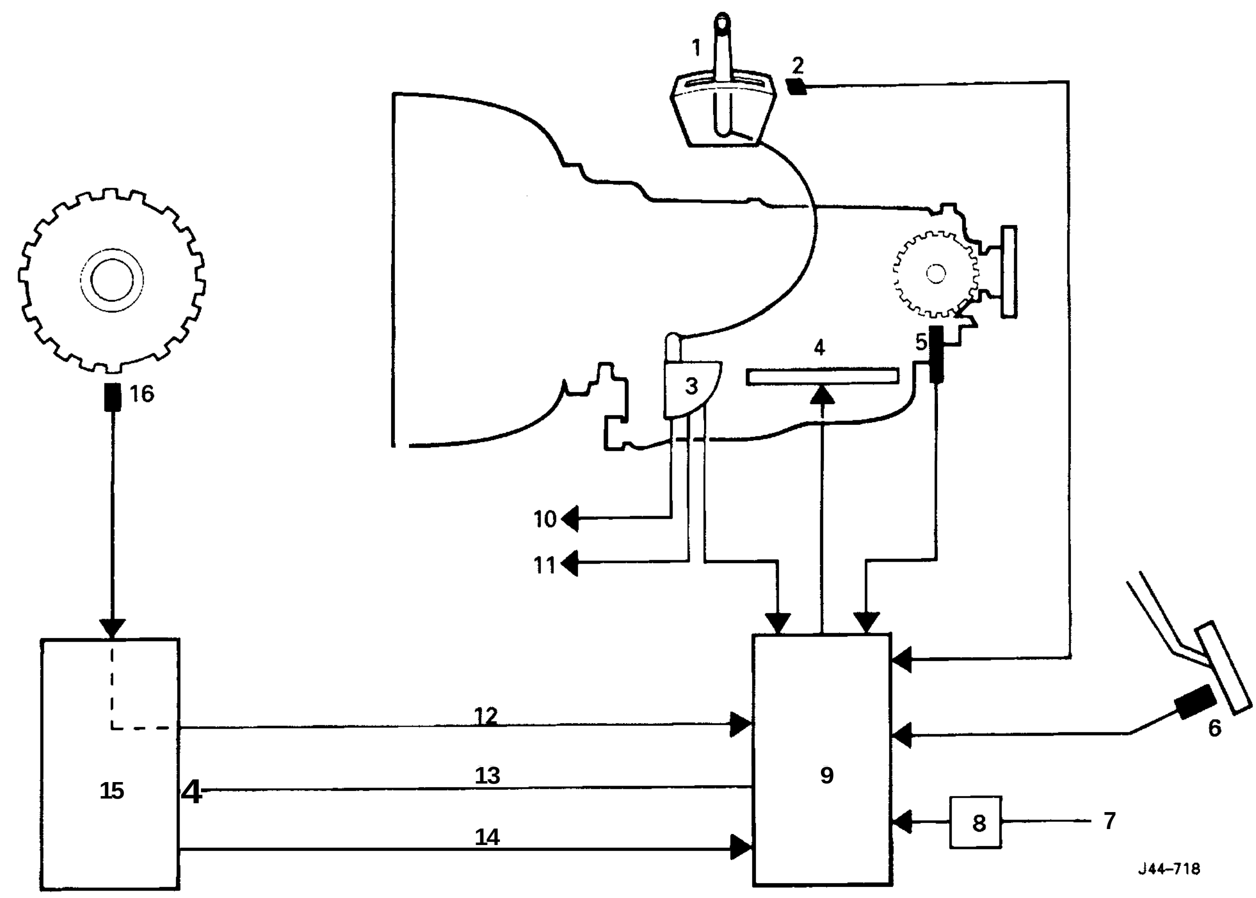
Fig. 1 Rear Valve Block



A. Modulator valve
B. Kick–down valve
C. Reverse inhibit valve

Note: Numerical annotations are not used in this application.

Fig. 1 Throttle Valve Block



1. Selector
2. Mode switch
3. Rotary switch
4. Transmission control unit
5. Output shaft speed sensor
6. Kick-down switch
7. Battery
8. Transmission relay
9. Transmission control module (TCM)
10. Reverse lamps
11. Start inhibiter
12. Engine speed
13. Ignition retard
14. Engine load
15. Engine control module (ECM)
16. Engine speed sensor

Fig. **1** Control Layout Schematic

2.1.5 Transmission Control Module (TCM)

The Transmission Control Module (TCM) is an electronic control unit located in the front passenger footwell behind the underscuttle pad. It is electrically connected to the transmission and other components through a cable harness and multiple pin plug.

The TCM continuously monitors the gear selected (via the rotary transmission switch), the speed of the output shaft (by speed sensor on the output shaft) and throttle position ('kick-down' switch). This information plus input from the Engine Control Module (ECM) of throttle angle and engine speed and load in conjunction with a pre-programmed control map, enables the most suitable gear to be selected.

The TCM, by operating solenoid valves MV1, MV2 and MV3, controls the gear shift speed and in conjunction with the solenoid operated pressure control valve, controls the gear shift quality. Gear shift quality on upshifts is improved by the TCM momentarily retarding the ignition to reduce the torque input as the gear change takes place. Information is fed to the TCM from sensors and if any electronic component fails, the basic shift changes will be performed by the hydro-mechanical system, ie Park, Reverse, Neutral, **D3** or **D4.**

?. *1.13 Harness Connections*

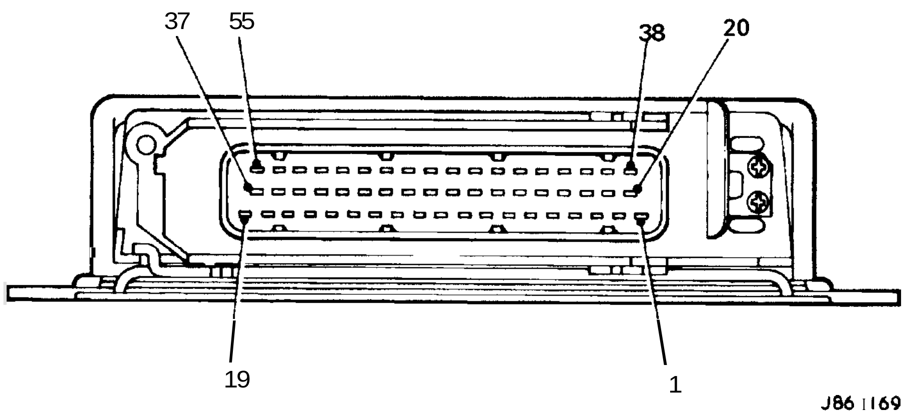


Fig. 1 Transmission Control Module Connections – Pin Locations

Pin	Function	Pin	Function
1	Power supply input	29	Program switch /Traction control input
2	Vehicle speed sensor plus input	30–31	not used
3	Engine speed input	32	Torque reduction T (I) output
4	Program switch input	33	Position code Z input
5	Solenoid valve MV1 output	34–37	not used
6	Pressure control valve PCV output	38	Vehicle speed sensor minus input
7	Digital ground input	39–40	not used
8–13	not used	41	Kick down switch input
14			
15	Diagnostic L–line	43	not used
16	Transmission malfunction indicator lamp output	44	Oil temperature sensor ground
17–18	not used	45	not used
19	Solenoid valves plus input	46	Oil temperature sensor input
20	Vehicle speed sensor screen	47	Throttle position input
21	Engine torque signal T(T) input	48	not used
22–23	not used	49	Sport mode indicator output
24	Solenoid valve MV2 output	50	Position code X input
25	not used	51	Diagnostics K–line
26	Power ground input	52–55	not used
27–28	not used		

2.1.14 Rotary Switch Harness

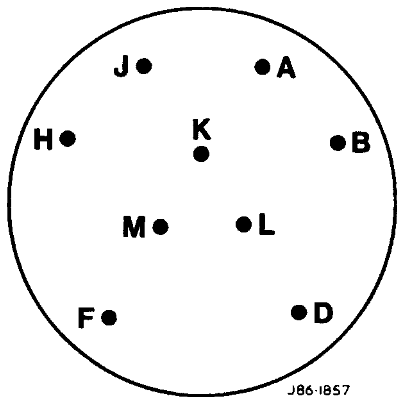


Fig. 1 Transmission Connector (9–way)

Pin	Color	Size (mm^2)	Function
A	UIN	0.5	Speed sensor (–)
B	OG	0.5	Pressure regulator solenoid valve
D	YG	0.5	Oil temperature sensor input
F	RIN	0.5	Speed sensor (+)
H	YB	1.0	Solenoid valve 1 (MV1)
J	BG	0.5	Oil temperature sensor ground
K	YP	1.0	Solenoid valve 2 (MV2)
L	YU	1.0	Lock–up solenoid (MVK)
M	RY	1.0	Solenoid supply

Color Code

N	Brown	Y	Yellow
B	Black	O	Orange
W	White	S	Slate
K	Pink	L	Light
G	Green	P	Purple
R	Red	U	Blue
I	Indigo		

2.1.15 Main harness connectors – 12 way & 8 way

Pin	Size (mm²)	Function
12–way connector		
1A	0.5	Switch common
2A	0.5	Code X output
3A	0.5	Code Y output
4A	0.5	Code Z output
5A	–	N / C
6A	–	N / C
7A	–	N / C
8A	0.5	Oil temperature signal
9A	0.5	Oil temperature ground
10A	0.5	Road speed screen
11A	0.5	Road speed sensor
12A	0.5	Road speed sensor

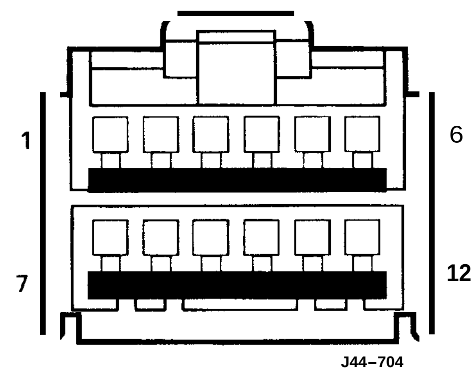


Fig. 1 Main Harness Connector – 12 way

Pin	Size (mm²)	Function
1B	1.0	Solenoids output
2B	1.0	MV1 solenoid
3B	1.0	MV2 solenoid
4B	1.0	MV WK solenoid
5B	0.5	Pressure regulator
6B	0.5	Start inhibit output
7B	0.5	Start inhibit ground
8B	0.5	Reverse lights output

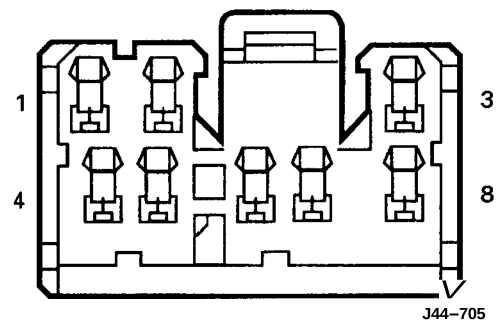


Fig. 2 Main Harness Connector – 8–way

2.2 HYDRAULIC CIRCUIT DIAGRAMS

Component Engagement

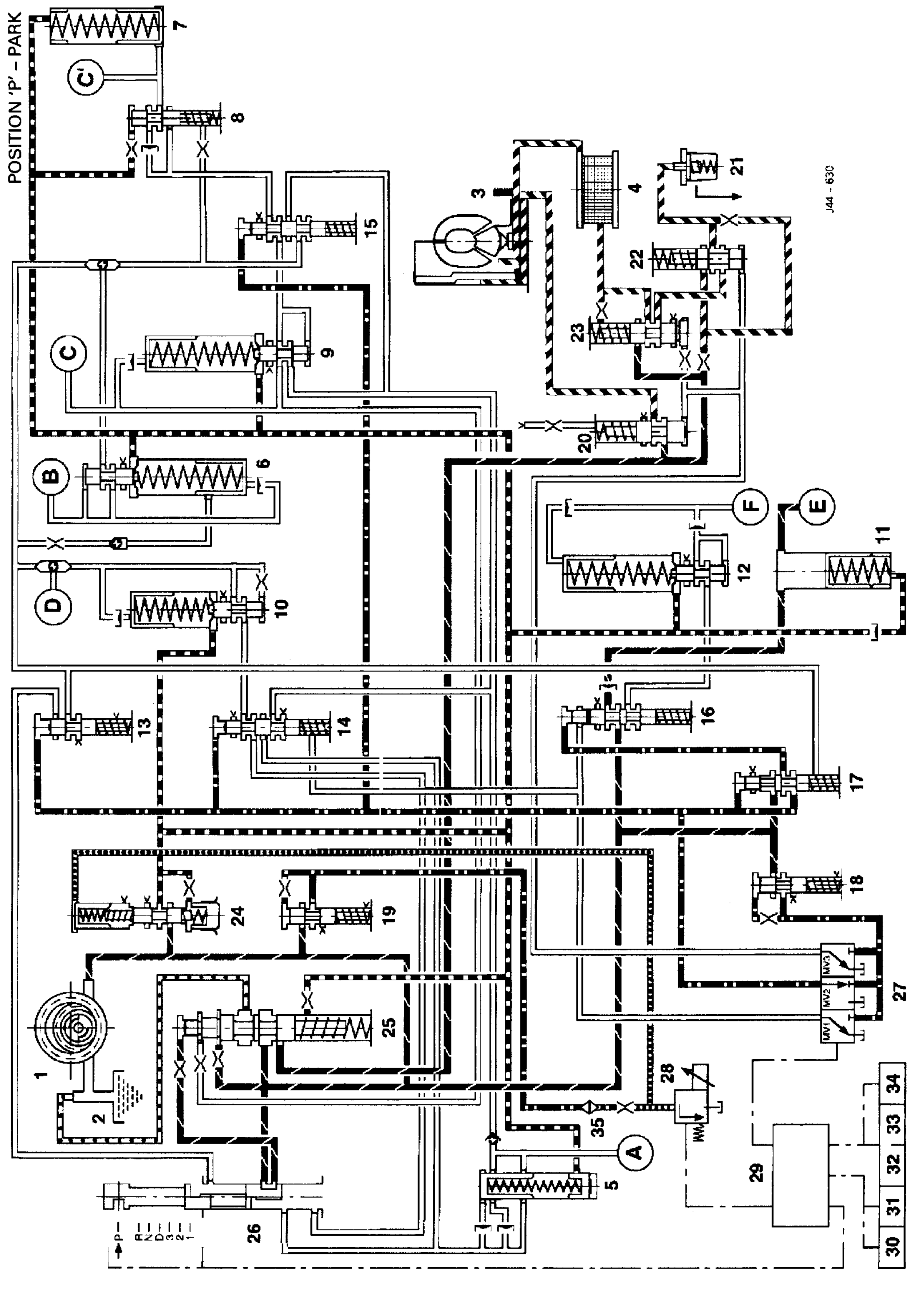
Selector Position	Gear	Solenoid Valves			Clutches							Free-wheel				Converter Clutch
		MV 1	MV 2	MV 3	A	B	E	C^1	C	D	F	G	H	J	K	
P			*				*									
R	R					*	*			*		*				
N			*				*									
D	1		*		*		*					*		*	*	
D	2	*	*		*		*	*	*			*	*		*	
D	3	*			*	*	*		*			*			*	
D	4			*	*	*			*		*	*				*
3	1		*		*		*					*		*	*	
3	2	*	*		*		*	*	*			*	*		*	
3	3	*			*	*	*		*			*			*	
2	1		*		*		*					*		*	*	
2	2	*	*		*		*	*	*			*	*		*	

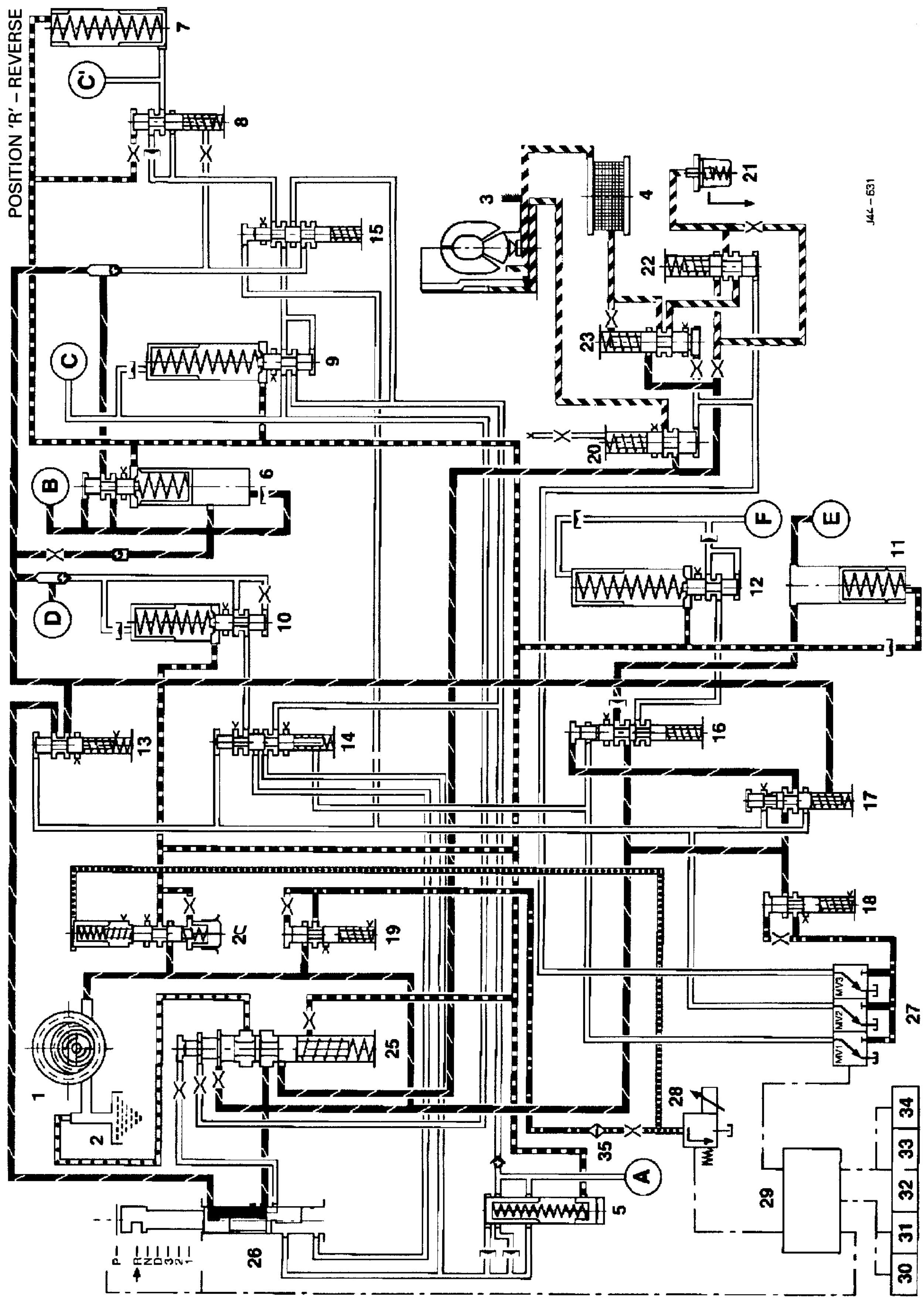
Key To Hydraulic Diagrams (commencing on page 52)

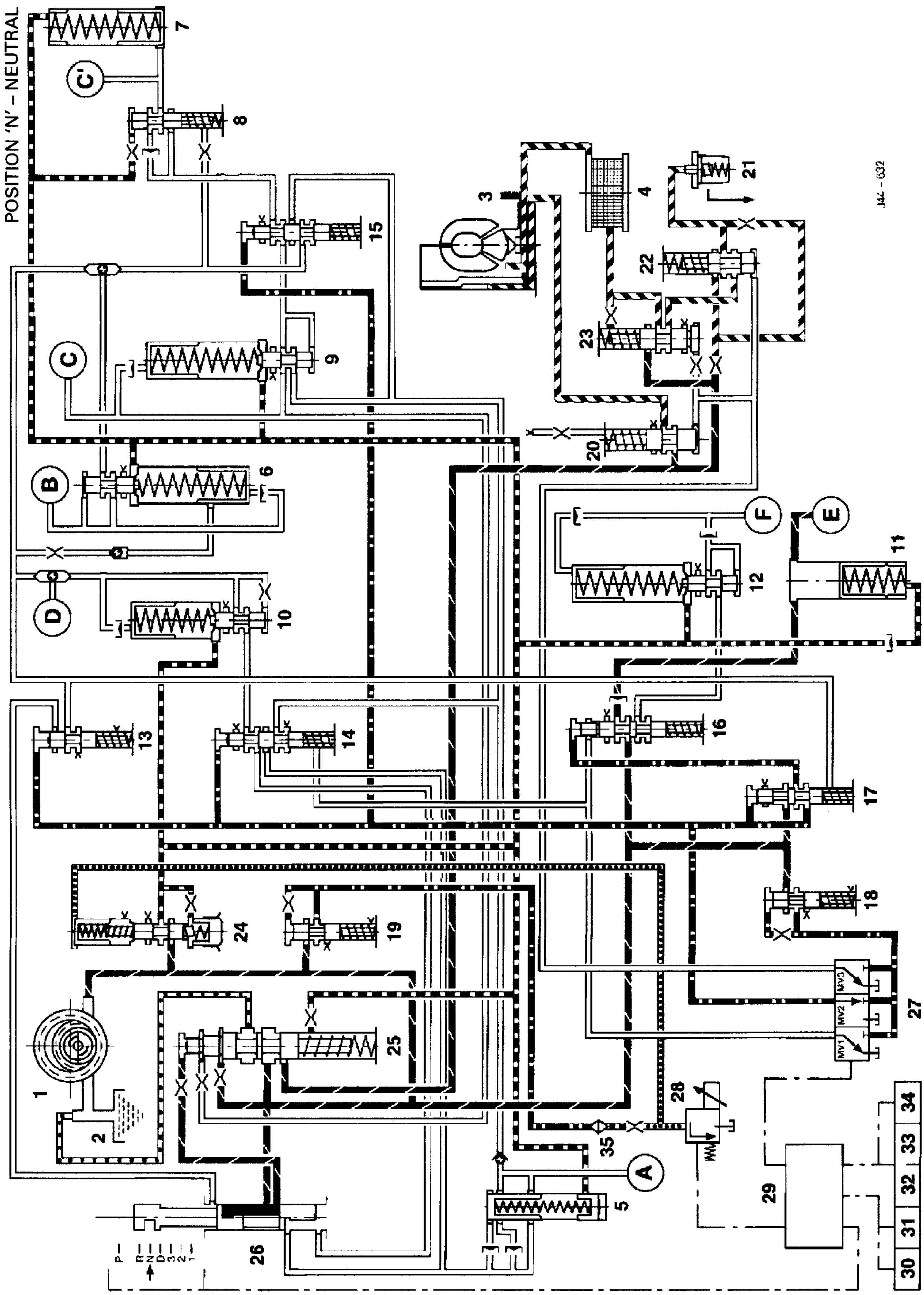
1. Oil pump
2. Sump
3. Torque converter
4. Olil cooler
5. Clutch 'A' damper
6. Clutch 'B' valve and damper
7. Clutch 'C^1' damper
8. Clutch 'C^1' valve
9. Clutch 'C' valve and damper
10. Clutch 'D' valve and damper
11. Clutch 'E' damper
12. Clutch 'F' valve and damper
13. Reverse locking valve
14. Shift valve 1 – 2
15. Shift valve 2 – 3
16. Shift valve 3 – 4
17. Safety valve
18. Pressure valve 1
19. Pressure valve 2
20. Torque converter pressure valve
21. Lubrication valve
22. Lubrication valve
23. Lock-up control valve
24. Modulation pressure valve
25. Main pressure valve
26. Gear change valve
27. Solenoid valves MV1/MV2/ MV3
28. Pressure regulator
29. ECM – inputs and outputs
30. Engine torque
31. Throttle valve
32. Engine speed (RPM)
33. Transmission speed (RPM)
34. Transmission rotary switch
35. Oil filter

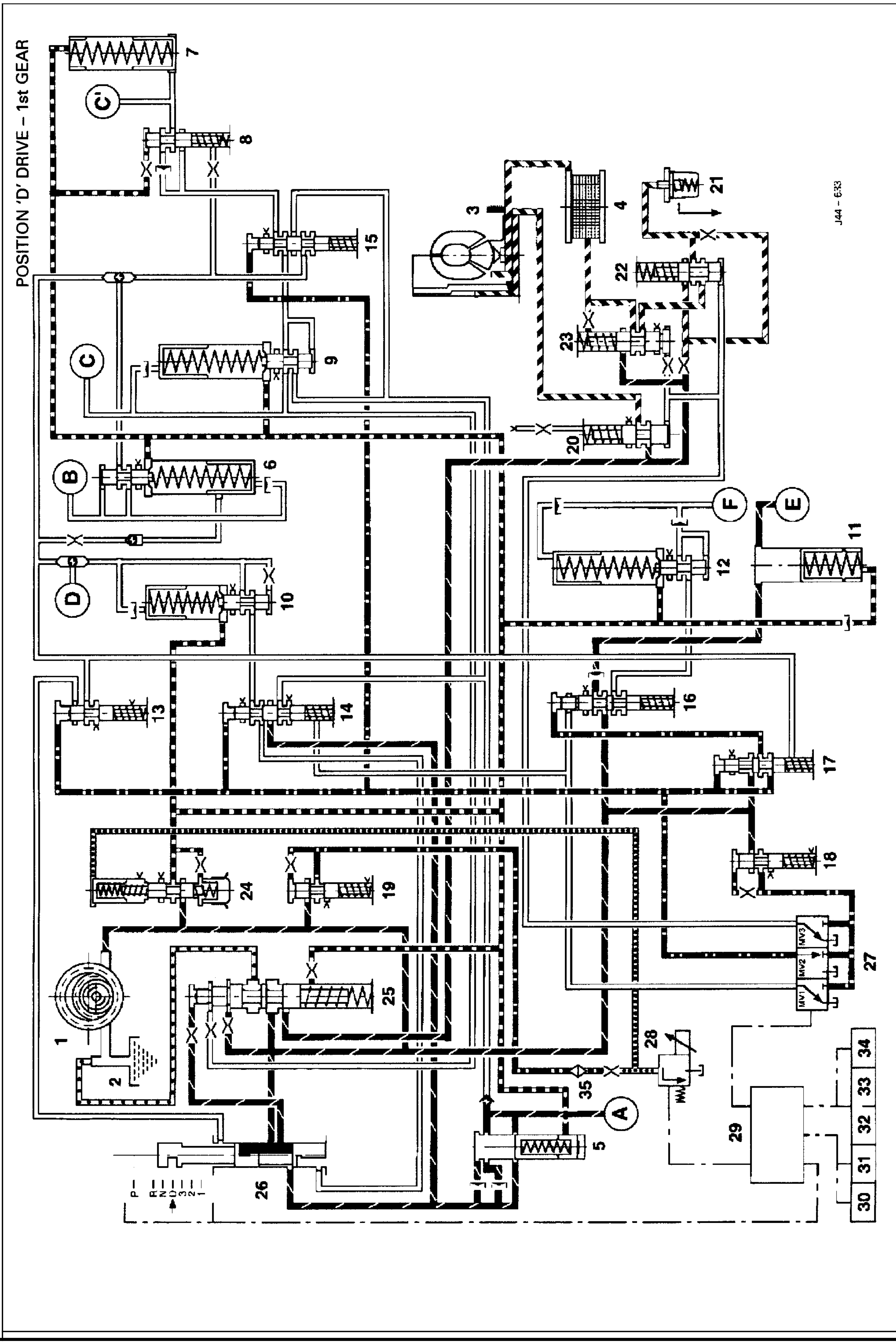
A Clutch 'A'
B Clutch 'B'
C Clutch 'C'
C^1 Clutch 'C^1'
D Clutch ' D
E Clutch 'E'
F Clutch 'F'
G Torque converter freewheel
H (C) Clutch freewheel
J (D) Clutch freewheel
K (E) Clutch freewheel

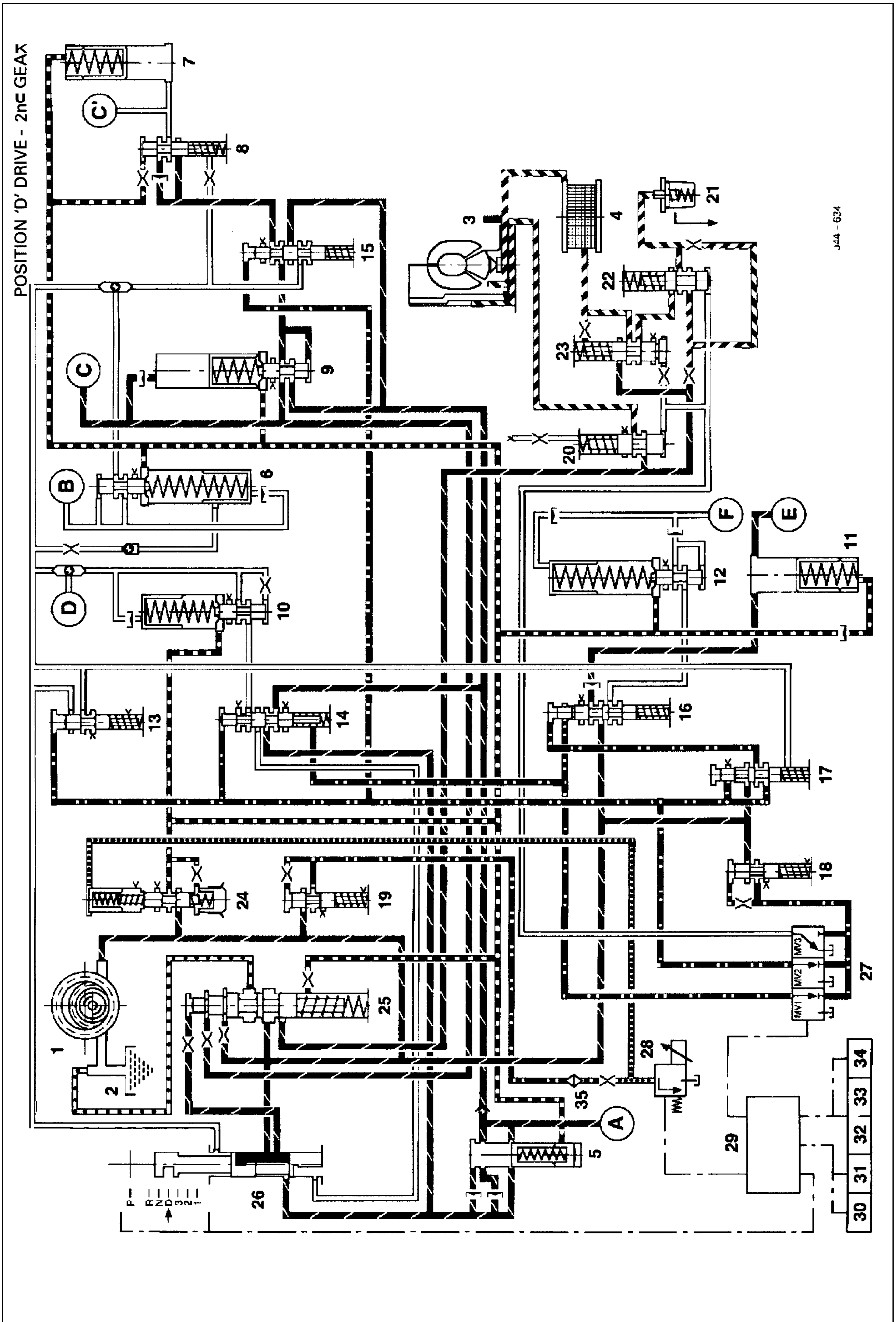
Exhaust
Throttle
Orifice
Main pressure
Converter pressure
Throttle pressure
Reduced pressure
Modulation pressure
Sump
Lubrication pressure

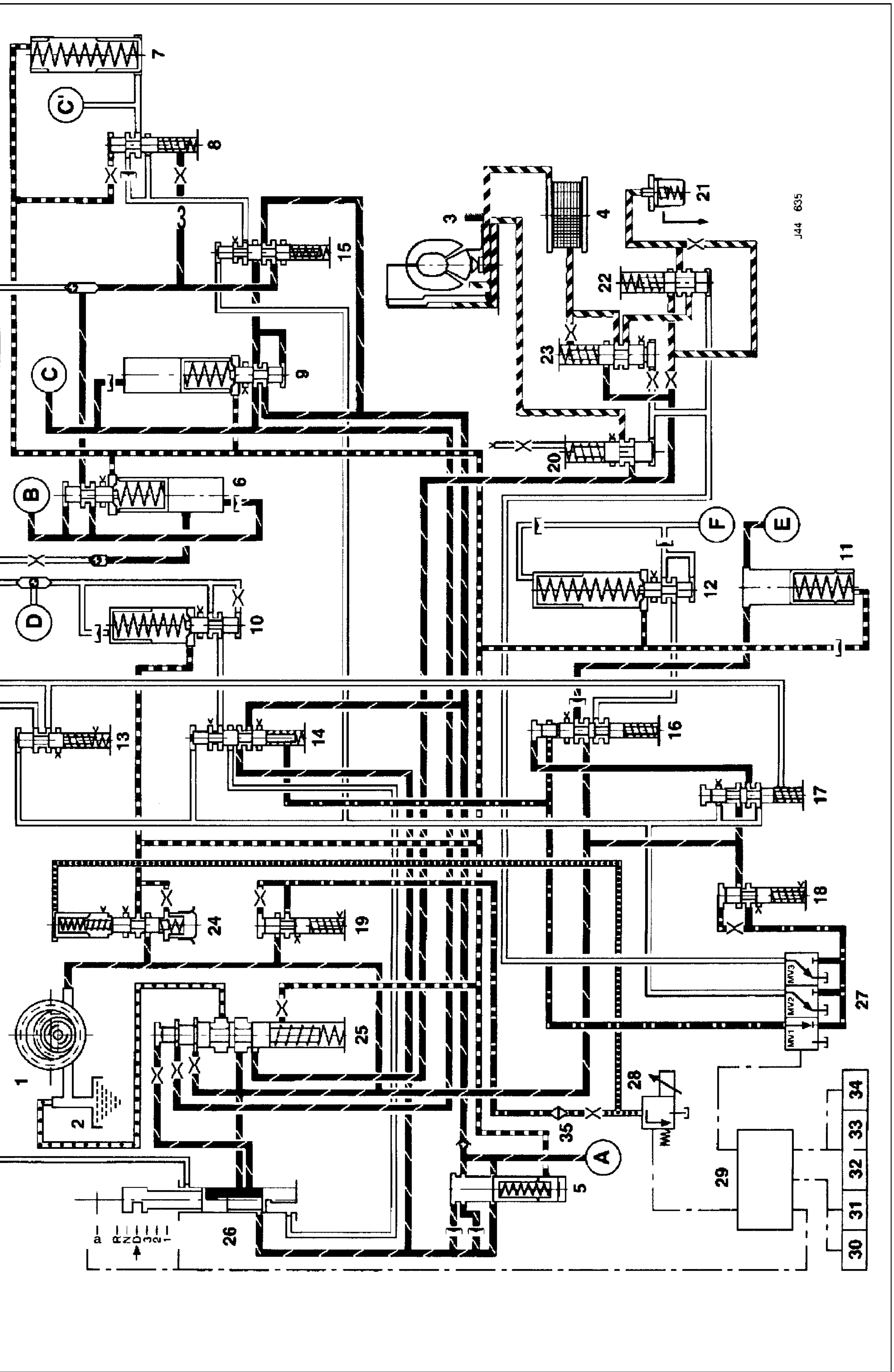

POSITION 'P' – PARK
A
B
C
C'
D
E
F
MV1
MV2
MV3
P
R
N
D
3
2
1
J44 - 630


POSITION 'R' – REVERSE
A
B
C
C'
D
E
F
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
MV1
MV2
MV3
P
R
N
D
3
2
1
J44 – 631

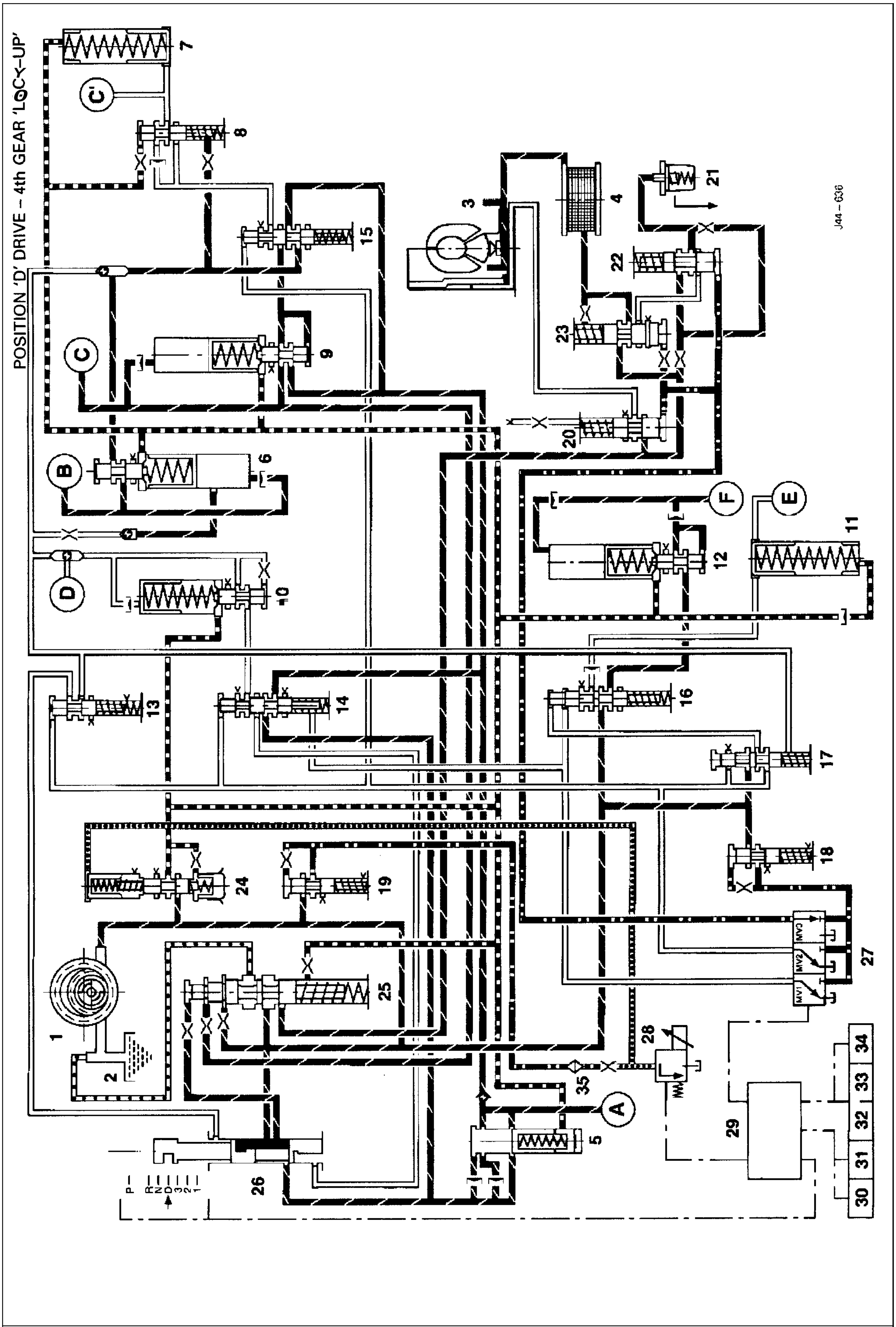

POSITION 'N' – NEUTRAL
A
B
C
C'
D
E
F
MV1
MV2
MV3
P
R
N
D
3
2
1

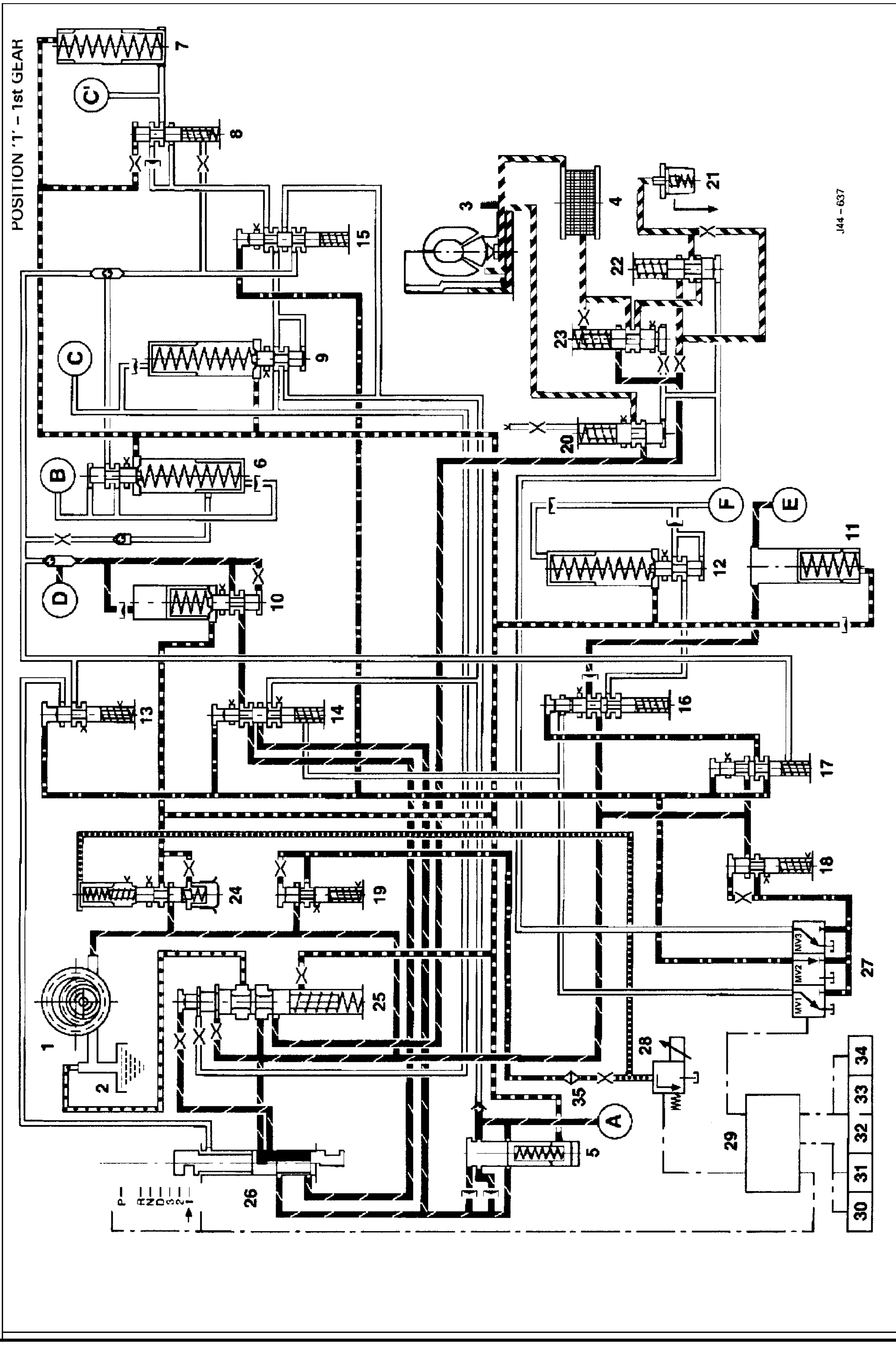

POSITION 'D' DRIVE – 1st GEAR
J44 - 633
A
B
C
C'
D
E
F
MV1
MV2
MV3
P
R
N
D
3
2
1
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35


POSITION 'D' DRIVE - 2nd GEAR
J44 - 624
A
B
C
C'
D
E
F
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
MV1
MV2
MV3
P
R
N
D
3
2
1



POSITION 'D' DRIVE – 3rd GEAR


POSITION 'D' DRIVE – 4th GEAR 'LOCK-UP'
J44-636


POSITION '1' – 1st GEAR
J44 - 637

2.3 FAULT DIAGNOSIS

The following tables are intended as a guide to diagnosis of possible faults in the ZF 4 HP 24 E transmission. When the fault involves a leak, it is recommended that it is located by the use of a crack detection fluid, eg. Met-L-Check, which is available in spray form and permits the leak to be located after a short test drive.

2.3.1 Initial Checks

Note: Before attempting fault diagnosis, ensure that the following settings are checked:

Transmission oil level

- Ensure that the transmission is at normal operating temperature, e.g. by conducting a 20 mile road test. If starting from cold: check for presence of oil on dipstick at idle in 'P' Park before setting off.
- Check that the vehicle is on level ground.
- Firmly apply the parking and footbrakes and run the engine at idle speed.
- To ensure that the system is primed, slowly move the selector lever through all the gear positions.
- With the engine still running, engage 'P' Park, withdraw the dipstick and wipe with a lint free cloth.
- Replace the dipstick slowly and withdraw it noting the level.
- Top up as required and recheck the level.

Note: The oil level can only be accurately checked when at normal temperature – approximately 20 miles at moderate speeds.

2.3.2 Engine Tune

Selector cable adjustment

- Check gear selection in all selector positions.
- If in doubt, select 'N', disconnect the cable at the gearbox selector lever, check that the gearbox lever is in 'N' position (third detent from the rear) and refit the selector cable ball pin to the lever.
- Adjust as necessary at the selector lever inside the vehicle.

2.3.3 Stall Test

- Ensure the transmission is at normal running temperature.
- Fully apply the parking brake.
- Start the engine.
- Fully depress the footbrake.
- Select position 'D' – Drive.
- Fully depress the accelerator ('kick-down' switch fully depressed).
- Note the tachometer reading.
- Compare the tachometer reading to the specification.

CAUTION: This test must not last more than 5 seconds. Always allow the engine to idle for at least 2 minutes between tests to allow the transmission fluid to cool down. Do not carry out more than three tests in any half-hour.

Jaguar Diagnostic Equipment (JDE) must be interrogated and any faults identified and rectified (see JDS Manual / Instructions). Check mode switch and gear selector positions using JDE.

2.3.4 Road Test

- Fully check all shift speeds and note. Compare the results with the specification in addition to general observations of transmission behaviour, noises, leaks etc., and consult the following Fault Finding Chart.

CAUTION: When renewing the transmission, ALWAYS flush out the oil cooler and feed and return pipes.

2.3.5 Electrical Checks

- Check 'Kick-down'.
- If any electrical component fault is suspected, refer to Electrical Diagnostic Manual (EDM) to verify the failure mode before a repair or replacement is attempted.

2.3.6 Fault Finding Chart

Problem	Possible Cause	Action
Stall speed too low	Stator freewheel faulty allowing stator to revolve Engine out of tune	Renew torque converter Check engine tune
Stall speed too high and keeps rising	Transmission slip Engine out of tune	Check oil level, check mechanical failure, renew transmission as necessary Check engine tune
Acceleration below specification	Torque converter freewheel faulty allowing stator to revolve. 'Kick-down' switch defective. Transmission in 'Limp Home' mode Engine out of tune	Renew torque converter. Refer to EDM, rectify / renew 'Kick-down' switch. Check. Check engine tune
Top speed below specification	Torque converter freewheel seized Engine out of tune	Renew torque converter Check engine tune
Position 'P' - Park		
Will not move out of Park	Gearshift interlock failure Check cable adjustment	Refer to EDM, rectify - renew fuse, check circuits, renew relay and solenoid. Check central 'P', check Park switch, check Brake switch. Adjust to correct setting
Does not engage Park	Parking pawl mechanism sticking Check cable adjustment	Renew park pawl components: connecting bar, pawl pin, torsion spring, pawl, guide piece and guide sheet. Adjust to correct setting
Does not hold	Parking pawl mechanism damaged	Replace park pawl components

2.3.6 Fault Finding Chart (continued)

Problem	Possible Cause	Action
Starter motor does not operate	Rotary switch adjustment. Rotary switch wiring fault. Rotary switch faulty. Position 'P' or 'N' not selected.	Adjust switch. Rectify. Rectify or renew. Select 'P' or 'N'.
Position 'R' - Reverse		
Reverse gear inoperative	MV2 faulty. Wire to MV2 earthed. Oil filter dirty. Damper 'B' faulty. Clutch 'B' faulty (also no 3rd gear). Clutch 'D' faulty. Clutch 'E' faulty (also no engine braking in 2nd and 3rd gears). Pressure regulator valve 1 binding Rotary switch wiring fault. Rotary switch faulty. Reverse gear inhibit valve activated. Main pressure control valve seized (also no forward drive in 'D' Drive).	Renew valve block. Renew harness. Clean / replace filter and flush out the oil cooler and pipes. Renew valve block. Renew transmission. Renew transmission. Renew transmission. Renew valve block. Rectify. Rectify or renew. Renew valve block. Renew valve block.
Slipping and juddering	'B' Clutch, 'D' Clutch or 'E' Clutch faulty. Pressure regulator valve 1 binding 'F' Clutch drum sealing rings faulty causing **loss** of 'E' Clutch pressure.	Renew transmission. Renew valve block. Renew transmission.
Harsh engagement 'P-R' change, 'N-R' change (below 1500RPM engine speed)	Damper 'B' faulty (also no 2nd to 3rd shift). Pressure regulator valve 1 binding Modulation pressure too high. Rotary switch faulty.	Renew valve block. Renew valve block. Check TCM Fault Codes. Rectify or renew.
Reverse lamp does not illuminate (bulbs, fuses and cables functioning correctly)	Rotary switch setting incorrect. Rotary switch faulty. Rotary switch wiring fault.	Adjust setting. Renew. Rectify.

2.3.6 Fault Finding Chart (continued)

Problem	Possible Cause	Action
Starter will not operate	Rotary switch faulty or incorrect setting. Rotary switch wiring fault.	Rectify or renew. Rectify Check Security System
Vehicle moves	'A' Clutch seized	Renew transmission
Drive not transmitted (neutral condition)	Oil filter dirty. Main pressure control valve seized. Low oil level. 'A' Clutch faulty. 'D' Clutch one-way clutch slips.	Clean / replace filter. Renew valve block. Check oil level. Renew transmission. Renew transmission.
Slipping and juddering at start	'A' Clutch faulty Low oil level.	Renew transmission. Check oil level.
Harsh engagement 'N'-'D' (under 1500RPM engine speed)	'A' Clutch faulty. 'A' Clutch damper faulty (5). Throttle pot. volts high. Rotary switch faulty / out of adjustment.	Renew transmission. Renew valve block. Check throttle pot. volts. Rectify or renew.
No 1st to 2nd upshift or 2nd to 1st downshift	MV1 wire earthed (remains in 2nd gear). MV1 faulty. Control circuit fault. Shift valve 1-2 seized. Pressure reducing valve 1 seized. Speed sensor or connectors faulty.	Renew harness. Renew valve block. Check TCM Diagnostics / rectify. Renew valve block. Renew valve block. Check connections, rectify or renew.
No upshift 1st to 2nd	Clutches 'C1' and 'C' faulty	Renew transmission
No upshift 2nd to 3rd or downshift 3rd to 2nd	MV2 wire earthed (remains in 2nd gear). MV2 faulty. Shift valve 2-3 seized. Speed sensor faulty.	Renew harness. Renew valve block. Renew valve block. Rectify or renew.
No upshift 2nd to 3rd	'B' Clutch faulty	Renew transmission

2.3.6 *Fault Finding Chart (continued)*

Problem	Possible Cause	Action
No upshift 3rd to 4th or downshift 4th to 3rd	Shift valve 3–4 seized. MV1 wire earthed. MV1 faulty. Speed sensor faulty.	Renew valve block. Renew harness. Renew valve block. Rectify or renew.
No upshift 3rd to 4th	'F' Clutch faulty	Renew transmission
Downshift 4th to 3rd too hard	Drain orifice 'F' partially blocked. Damper 'E' faulty.	Renew valve block. Renew valve block.
Manual gearshift D to 3rd too hard	Damper 'E' faulty. Drain orifice 'F' partially blocked.	Renew valve block. Renew valve block.
Manual gearshift 3rd to 2nd too hard	Damper 'C1' faulty	Renew valve block
No 1st gear; 2nd gear start only.	Speed sensor faulty. MV1 faulty. MV1 wire earthed. Shift valve 1–2 seized. '1st Gear Inhibit' circuit operated or 'Performance Mode' switch faulty.	Check or renew speed sensor. Renew valve block. Renew harness. Renew valve block. Operate 'Performance Mode' switch to correct function or renew switch.
No 1st or 2nd gear; 3rd gear start only	Transmission 'Limp Home' mode. Speed sensor faulty. MV1 or MV2 faulty. Shift valves 1–2 and 2–3 seized.	Check Diagnostics/ JDS. Renew speed sensor. Renew valve block. Renew valve block.
No 2nd gear; transmission shifts 1st to 3rd gear	Speed sensor faulty. Shift valve 2–3 seized.	Check or recheck Diagnostics, renew speed sensor. Renew valve block.
Light throttle gear change speeds incorrect	Shift valves sticking. Speed sensor faulty. Throttle pot. volts incorrect. Transmission Control Module (TCM).	Renew valve block. Check or renew speed sensor. Check voltage – JDS. Check TCM Diagnostics.
Up to 'kick-down' detent, gear change speeds not to specification	'Kick-down' switch out of adjustment	Readjust 'kick-down' switch

Problem	Possible Cause	Action
No 'kick-down' change	'Kick-down' switch out of adjustment/ full throttle stop adjustment. 'Kick-down' switch faulty. 'Kick-down' switch connector or wiring faulty.	Adjust as per Engine Set Up procedure on JDS. Renew 'kick-down' switch. Rectify.
Light throttle speeds only	TCM faulty	Check TCM
Light throttle gear change too hard	Valve block bolt torque incorrect. Modulation pressure too high. Damper faulty. Clutch plates faulty.	Reset to correct torque. Renew valve block. Renew valve block. Renew gear unit.
1st to 2nd, 2nd to 3rd and 3rd to 4th changes too long	Valve block bolt torque incorrect. Damper faulty. PRSV faulty. PRSV wire earthed. Modulation valve seized. Pressure regulator valves 1 and 2 seized.	Reset to correct torque. Renew valve block. Renew valve block. Renew harness. Renew valve block. Renew valve block.
Full load and 'kick-down' changes too long	Valve block bolt torque incorrect. Modulation pressure too low. Clutch plates faulty.	Reset to correct torque. Renew valve block. Renew transmission.
Full load and 'kick-down' changes too hard	Valve block bolt torque incorrect. Modulation pressure too low. Clutch plates faulty.	Reset to correct torque. Renew valve block. Renew transmission.
No engine braking	Clutch 'C1' or Clutch 'E' faulty	Renew transmission
Manual gearchange 3rd to 2nd inoperative	Speed sensor faulty. MV2 faulty.	Check TCM Diagnostics/ renew speed sensor. Renew valve block.

2.3.6 *Fault Finding Chart (continued)*

Problem	Possible Cause	Action
Converter clutch		
Clutch engagement speed ncorrect	Control circuit fault. Speed sensor faulty.	Check TCM Diagnostics / rectify fault. Check TCM Diagnostics / renew speed sensor.
ingagement too hard	Valve body problem. Converter unit faulty	Renew valve body Renew converter unit
No clutch engagement	Control circuit fault MV3 faulty. Converter clutch valve seized. Converter faulty. Pressure reducing valve 1 seized.	Check TCM Diagnostics / rectify fault. Renew valve block. Renew valve block. Renew converter. Renew valve block.
Converter clutch engaging at dle (engine will not idle in 'D')	Incorrect oil level. Oil filter not sealing. Control circuit fault. MV3 faulty. MV3 wire earthed. Converter clutch valve sticking.	Check oil level. Check 0-ring etc. Check TCM Diagnostics / rectify fault. Renew valve block. Renew harness. Renew valve block.
Oil in bell housing	Oil pump seal leaking. Oil pump 0-ring leaking. Pump housing leaking. Converter seam leaking.	Renew oil pump seal. Renew 0-ring. Renew oil pump. Renew converter.
Leakage between gearbox and sump	Loose fastening screws. Sump gasket faulty.	Torque tighten. Renew gasket.
Leakage between intermediate plate and gearbox	Bell housing to gearbox screws loose	Torque tighten
Leakage at harness plug connector	Connector 'O'ring faulty	Renew 'O' ring
Leakage at drive flange	Rear oil seal faulty	Renew oil seal

2.3.6 Fault Finding Chart (continued)

Problem	Possible Cause	Action
Leakage at breather	Oil level too high. Incorrect oil specification. Breather cover missing. Breather cover 'O' ring faulty. Breather cover loose.	Rectify. Change oil and flush system. Replace breather cover. Renew 'O' ring. Renew lockwasher.
Leakage from oil cooler circuit	Pipe lock nuts loose. Pipe line faulty. Oil cooler leaking.	Torque tighten. Renew relevant pipes. Renew oil cooler.
Leakage at intermediate plate	Intermediate plate plug leaking	Torque tighten plug. Renew sealing washer.
Leakage between gearbox and extension housing	Fastening screws loose. Gasket faulty.	Torque tighten Renew gasket.
General		
Noise and associated interruption of power	Oil filter dirty	Clean / replace filter. If clutch debris found, renew transmission, flush cooling system
Loud noise with no drive forward or reverse	Drive plate to converter connection damaged. Pump drive damaged.	Renew drive plate and converter as necessary. Renew transmission.
Groaning or buzzing noise (can sound like mechanical damage) in all selector positions, especially when cold. Sucking noise from pump.	Oil level too low. Valve block leaking.	Rectify. Renew valve block.
Loud noise on converter clutch engagement	Torsion damper defective	Renew converter
Engine vibrations when converter clutch engaged	Change point too low	Check TCM

2.4 SERVICE OPERATIONS

2.4.1 ZF 4 HP 22 Transmission

[SROs to be added when available]

2.4.2 ZF 4 HP 24 E Transmission

[SROs to be added when available]

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